BACTERIOLOGICAL SURVEYS OF THE LAKE HURON NEARSHORE INCLUDING THE NORTH CHANNEL, GEORGIAN BAY AND DOUGLAS POINT 1973-1975

Ontario
Ministry of the Environment

The Honourable
Harry C. Parrott, D.D.S.,
Minister

Graham W. S. Scott,
Deputy Minister

A BACTERIOLOGICAL STUDY OF THE ONTARIO NEARSHORE AREAS OF LAKE HURON 1974-75 SURVEY

(including the North Channel and Georgian Bay)

MICHAEL YOUNG

ANDREA TOTH

SUSAN JANHURST

GREAT LAKES UNIT

MICROBIOLOGY SECTION

MINISTRY OF THE ENVIRONMENT

DECEMBER 1977

TABLE OF CONTENTS

LIST OF FIGURES

ABSTRACT

Surveys to determine the quality of the nearshore waters of Lake Huron and Georgian Bay were conducted by the Ontario Ministry of the Environment in 1974. Included in this work was the study of the concentrations of sanitary indicator bacteria (total coliforms, fecal coliforms and fecal streptococci) Pseudomonas aeruginosa and aerobic heterotrophic bacteria.

The water quality of most of the area surveyed was good with bacterial levels similar to those of offshore waters. Exceptions were found in certain embayment and/or harbour areas adjacent to or downstream from centres of human habitation. Few of these areas had bacterial levels exceeding present I.J.C. or M.O.E. criteria though definite degradation of water quality was indicated. In most instances the degradation appeared to be the result of improperly treated municipal waste, e.g. Blind River, Owen Sound and Goderich, though industrial pollutants may be having an affect on water quality in at least two locations and recreational activity on the water quality of another.

Recommendations stemming from these studies included the need for development of new bacterial water quality standards for the nearshore waters, the use of more intensive localized surveys to study specific problem areas and the use of sulfur-cycle bacteria to establish the effect of certain industrial effluents.

INTRODUCTION

Surveys of the Ontario nearshore area of Lake Huron (Fig. 1) were conducted in 1974 with some additional work in 1975. The surveys were part of continuing Ontario Ministry of the Environment programs to monitor Great Lakes water quality and were developed to provide an input to the International Joint Commission Upper Great Lakes Study. They were designed to identify existing or developing problem areas and establish baseline levels against which future improvement or deterioration could be measured.

The overall survey area is divided into three geographically distinct regions. These are: the North Channel (Fig. 2A), extending from St. Joseph Island to Little Current; Georgian Bay (Fig. 2B), reaching from Little Current to Tobermory and also including the Penetanguishene-Waubaushene Bay (Fig. 2C); and Lake Huron (Fig. 2D), stretching along the southeastern shore from Tobermory to Sarnia.

The North Channel is enclosed by the mainland on the north, St. Joseph Island on the west and Manitoulin Island along the south. The channel receives waters from Lake George, St. Mary's River, The Mississaugi, Serpent and Spanish Rivers. The main urban centres along the channel are: Thessalon, Blind River and Little Current.

Georgian Bay is an oval shaped bay stretching in a southeasterly direction with many small inlets and bays along the shores. There are a large number of rivers flowing into the bay; the main ones being the French River and the Severn-Trent Canal System. The major towns along the eastern shore are Britt, at the mouth of the Magnetawan River and Parry Sound in Parry Sound Harbour (Fig. 2E). In the Penetanguishene-Waubaushene area, the densest populations are Victoria Harbour, Waubaushene, Port McNicoll, Midland and Penetanguishene. Along the southern and western shores, the major urban centres are Wasaga Beach, Collingwood, Thornbury, Meaford, Owen Sound and Wiarton. There are several provincial and national parks along the shores. In Tobermory, at the tip of Bruce Peninsula, there are operational ferry docks.

...2

FIGURE 1 - LOCATION OF THE SURVEY AREA IN THE GREAT LAKES

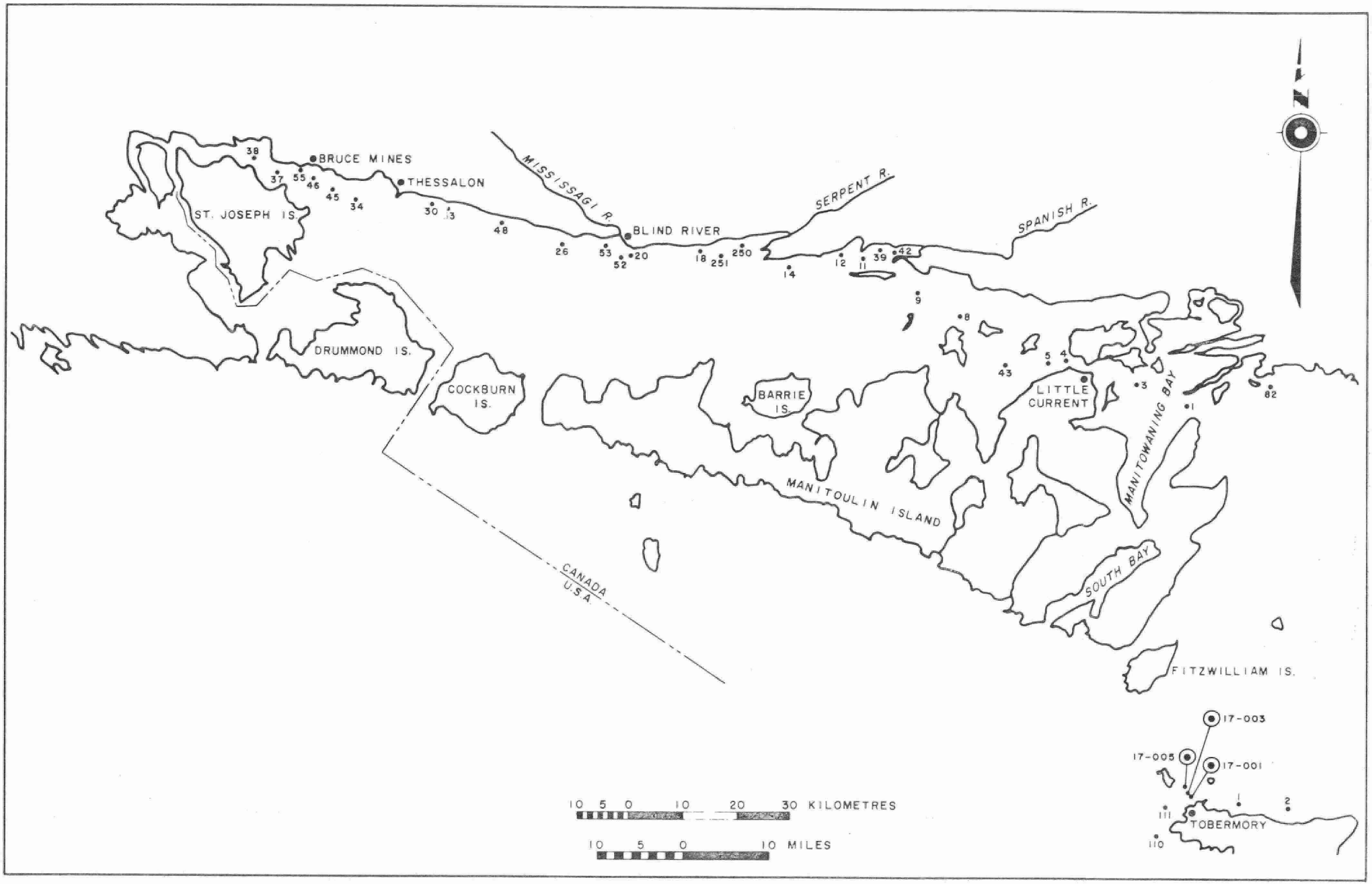


FIGURE 2A - 1974 NORTH CHANNEL SAMPLING POINTS

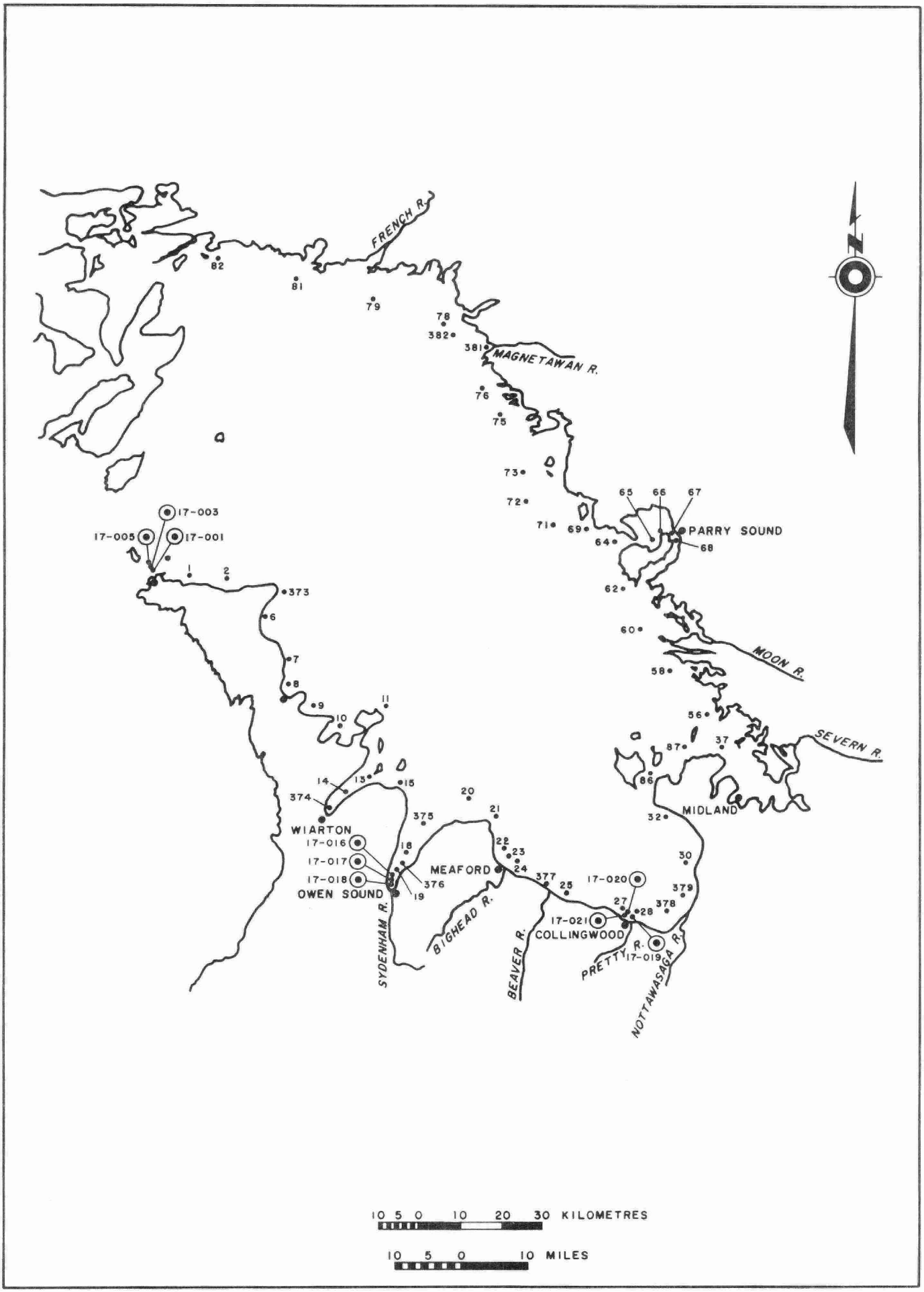


FIGURE 2B - 1974 GEORGIAN BAY SAMPLING POINTS

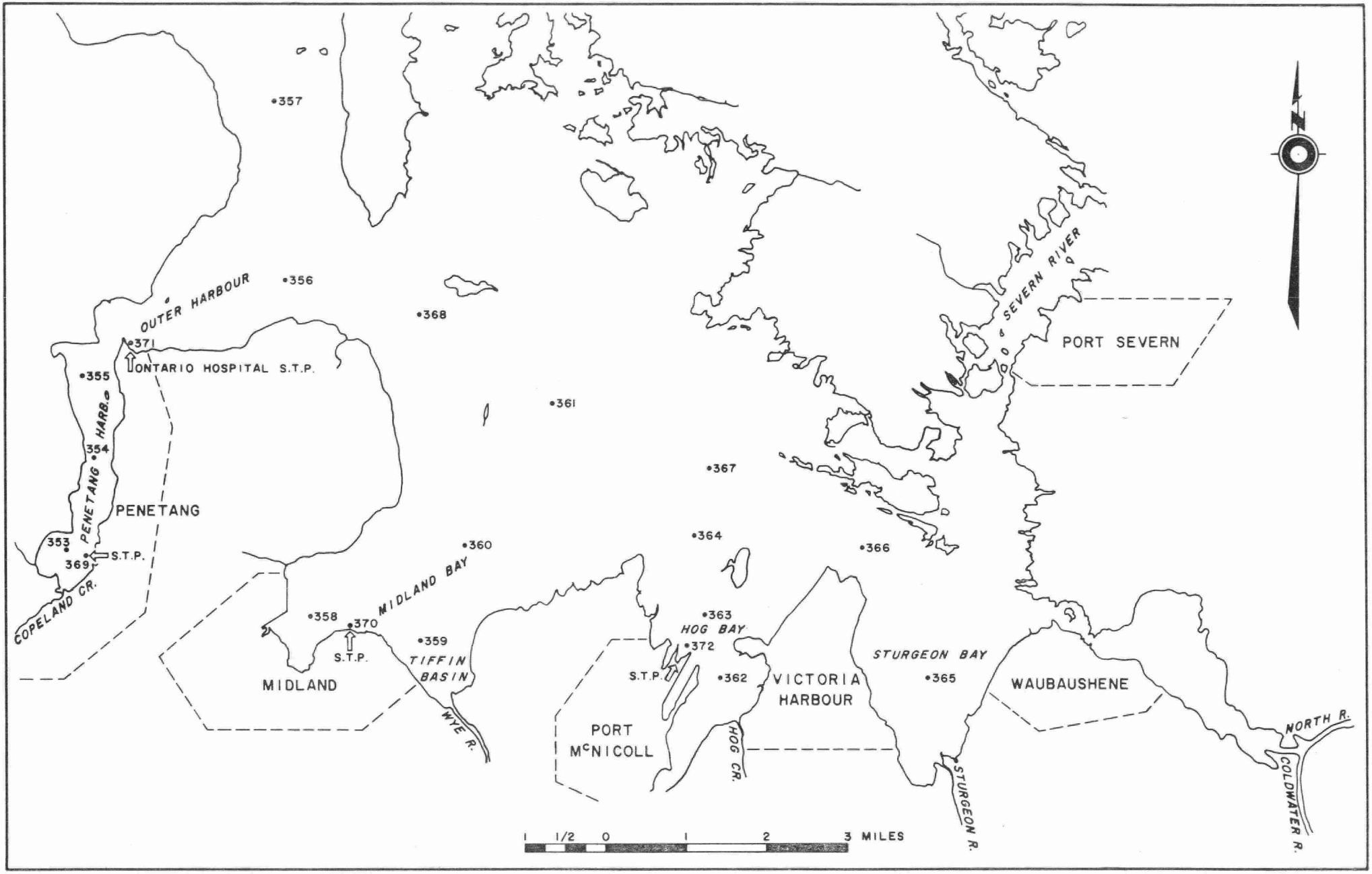


FIGURE 2C - 1974 PENETANG-WAUBAUSHENE SAMPLING POINTS

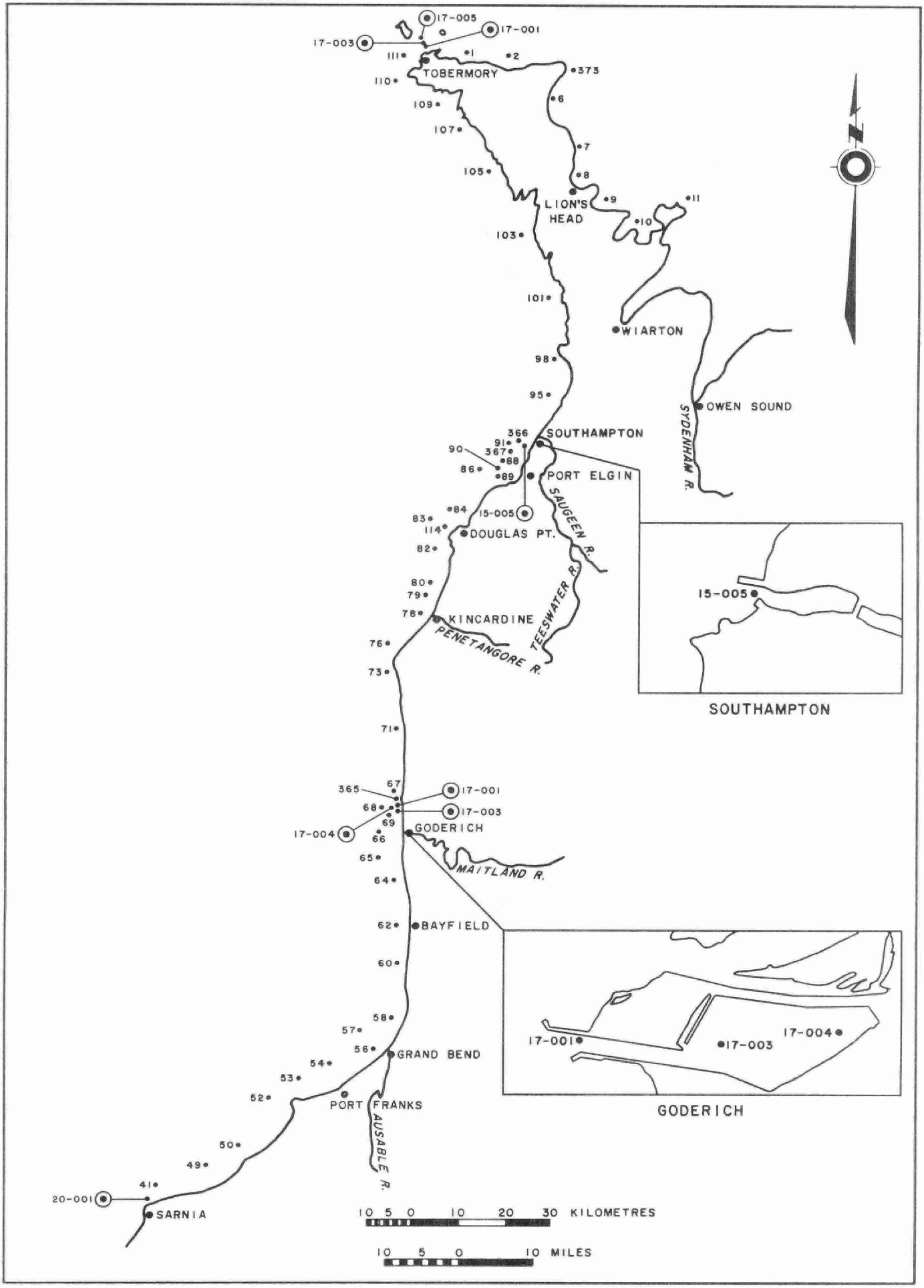


FIGURE 2D - 1974 LAKE HURON SAMPLING POINTS

FIGURE 2E - 1974 PARRY SOUND HARBOUR SAMPLING POINTS

The surveys conducted in Lake Huron ran along the eastern shores to the lake's most southern tip at Sarnia. The major urban developments along the shores are Southampton, Port Elgin, Kincardine, Goderich, Point Edward and Sarnia. At Douglas Point (Fig. 2F), there is a nuclear generating plant.

METHODS

Field Procedures:

Bacteriological samples were taken at 28 stations in the North Channel, 92 stations in Georgian Bay and 62 stations in Lake Huron (Figs. 2A-F).

The North Channel was monitored with single samples from June 23 to June 25, 1974. A second three-day survey was conducted from July 14 to July 23, 1974. A final survey of the channel consisting of only single samplings was performed from October 28 to November 6, 1974.

One survey of the entire area of Georgian Bay was conducted in a three-day series from May 22 to June 23, 1974. A second complete survey ran from August 2 to September 10, 1974 with triplicate samplings. A third survey began at Little Current on November 11 in a one-day series and was completed at Parry Sound. Six additional stations were monitored in Parry Sound Harbour for three consecutive days, ending on November 27, 1974.

A monitoring of the Lake Huron stations between Sarnia and Tobermory took place from May 9 to May 21, 1974. A second single sampling of the stations from Sarnia to Goderich began on October 3 and ended on October 10, 1974.

The stations that were monitored were chosen along the shoreline with particular bias towards sources of input (STP, rivers, etc.). Surface and depth samples were collected at each station. Surface samples were collected at approximately 1.5 meters below the surface of the lake in sterile 6 ounce glass

...3

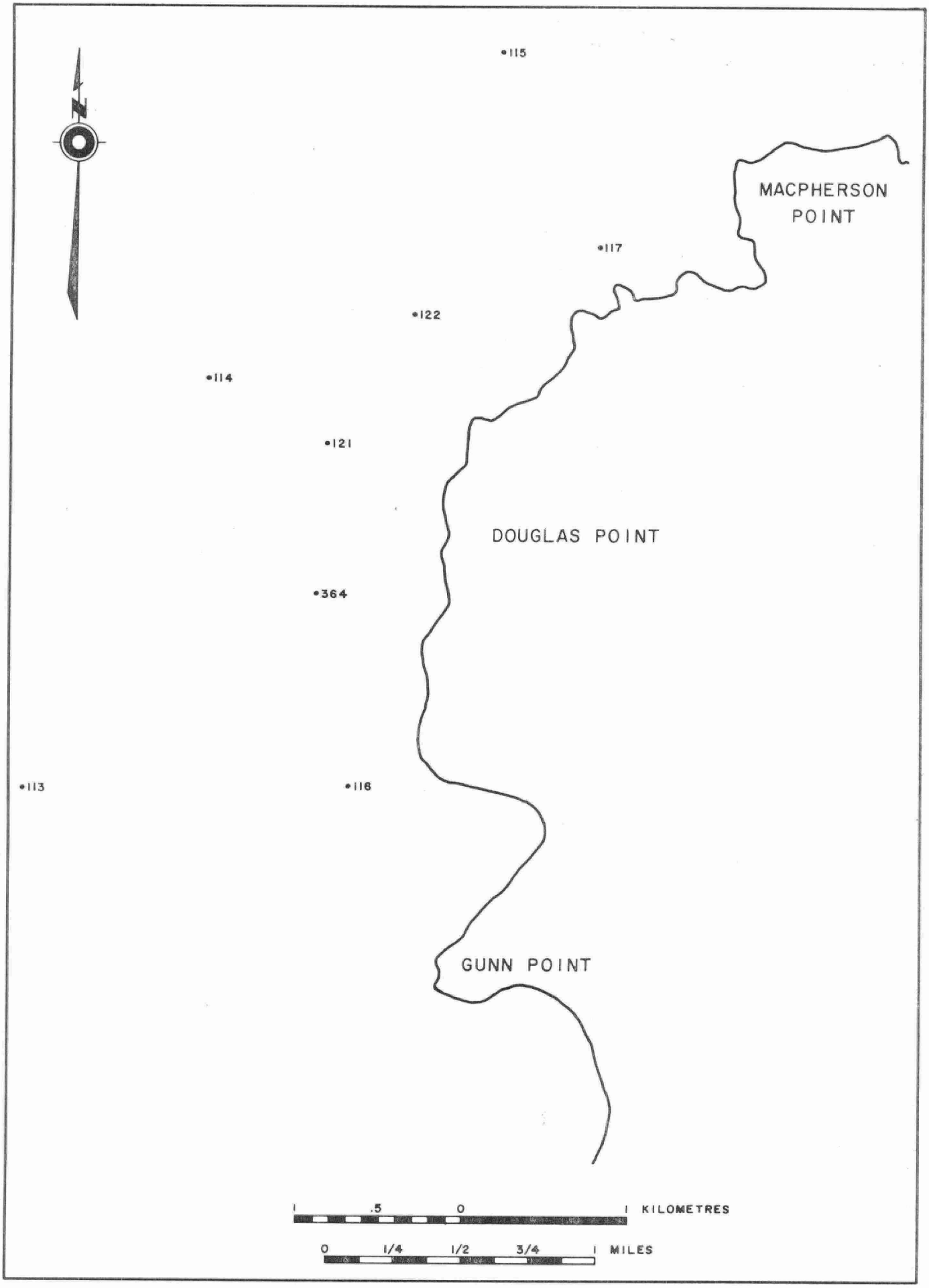


FIGURE 2F - 1974 DOUGLAS POINT SAMPLING POINTS

bottles. All depth samples were taken at the mid-hypolimnion, except during the spring survey when a few stations between Tobermory and Wiarton were also sampled at two meters off bottom. The depth samples were collected in sterile 237 ml evacuated rubber syringes. The samples were immediately put on ice and transported to the laboratory.

The North Channel samples were analyzed in the mobile laboratory which was stationed in Sault Ste. Marie. The Georgian Bay samples were analyzed in the mobile laboratory which was located in Barrie for the first week of the May-June survey and in Penetanguishene for the remainder of this survey and for all of the August-September survey. All the November survey samples were transported to the Toronto M.O.E. laboratory. Lake Huron samples were taken to the southwestern regional M.O.E. laboratory in London for analyses.

Lab Procedures:

All samples were analyzed for total coliform (TC), fecal coliform (FC) and fecal streptococcus (FS). Analyses for these parameters were performed within twenty-four hours of sampling and counts were recorded as number of organisms per 100 ml.

Membrane filtration methods were performed according to Standard Methods (13th edition) [1], using M-Endo Agar LES (Difco) for TC, MacConkey Membrane Broth (Oxoid) for FC and M-enterococcus Agar (Difco) for FS.

In addition, a determination of the heterotrophic bacterial population (HB) was performed within twelve hours of sampling. Analysis was done on a modified Foot and Taylor Agar (Appendix I) using the spot plate technique. Incubation was for seven days at 20°C and counts were recorded as number of organisms per 1 ml. This parameter was used in the first survey of each area, the second North Channel survey and the 1975 Lake Huron survey.

....4

Pseudomonas aeruginosa was used as a survey parameter for the first 1974 survey of the North Channel and Georgian Bay and for the 1975 Lake Huron survey. The method used was the membrane filtration procedure of Levin and Cabelli (mPA). The incubation was at 41.5°C for 48 hours (2).

Statistical Methods:

Fluctuation in bacterial concentrations due to changing environmental conditions require that a great number of samples be taken to arrive at a mean value which is representative of a specific sample location or sampling area. The most appropriate mean for bacterial levels and this type of data is the geometric mean (GM). The large amounts of data generated from these surveys require that statistical methods be utilized to summarize the results concisely and to facilitate an unbiased interpretation.

Once the station group statistics had been obtained, an analyses of variance program (ANOVA) was used to group the stations into areas within the same statistical bacterial level. The ANOVA analyses were first performed on all survey stations. If the calculated F-ratio was less than the critical F-ratio (0.05 level), the stations were considered statistically the same and were summarized as a group with one set of overall group statistics. At the same time as the ANOVA analyses were performed, the homogeneity of the variance was also checked using Bartlett's X^2 test of homogeneity. If either the F or X^2 values were significant, then stations were withdrawn until both were non-significant. The statistics were then repeated on the withdrawn stations until all stations had been properly grouped. The Student-t test (using GM and SE) was used to compare overlapping homogenous areas between each of the surveys.

...5

Criteria:

The criteria considered permissible for public surface water supplies when full treatment is supplied for the three sanitary indicator bacteria: total coliform, fecal coliform, fecal streptococcus and for heterotrophic bacteria are a maximum geometric mean of 5,000, 500, 50 and 100,000 per 100 ml respectively. The maximum permissible levels for private water supplies requiring chlorination only are 100, 10, 1 and 1,000 per 100 ml respectively, while that for waters requiring chlorination and filtration are 400, 40, 4 and 4,000 per 100 ml.

The Recreational Use criteria states that: "Where ingestion is probable, recreational waters can be considered impaired when the coliform, fecal coliform, and/or enterocococcus geometric mean density exceeds 1,000, 100 and/or 20 per 100 ml respectively ...". The geometric mean of the FS results is mainly used in a ratio with the corresponding FC geometric mean (FC/FS) to gain information on the source (human or non-human) of pollution within areas adjacent to or at input. If this ratio is greater than 4.0, the source of bacterial contamination is likely of human origin. If the ratio is less than 0.7 then the source is most likely non-human (3). It should be noted that this ratio is used to determine the source of pollution and not the safety of the water as animals are a potential source of organisms pathogenic to humans.

RESULTS AND DISUCCION

North Channel

In 1974, three surveys were conducted in June, July and October to determine the water quality of the North Channel. However, since only one piece of data was obtained for each station during the June and October surveys, the results were not statistically analyzed and thus the groups calculated for July were arbitrarily chosen as representative.

...6

In June (Fig. 3), the North Channel, apart from the Blind and Spanish River areas, had TC, FC and FS levels from 1-2/100 ml. The Blind River area (Group B) had 21 TC, 4 FC and 2 FS/100 ml, while the Spanish River area (Group D and Station 42) had 16-95 TC, 2-6 FC and 1 FS/100 ml. Blind River (Stn. 53, 32 and 20) was the only area where P.aer. was isolated (3/100 ml).

The HB concentrations generally ranged from 1,000-1,600/ml for most of the channel, except for St. Joseph Island (Stn. 38), where the St. Mary's River flows in and the mouth of the Spanish River (Group D, Stn. 42). These sections had densities from 4,580 to 5,980 HB/ml.

In July (Fig. 4), water quality remained good throughout most of the area with only a small increase in FS occurring. TC, FC and FS levels ranged from 1-9, 1-10 and 1-3/100 ml respectively. However, at Blind River (Group B: 60 TC, 10 FC, 3 FS/100 ml) and the mouth of the Spanish River (Group D: 246 TC/100 ml and Stn. 42: 246 TC, 8 FC and 29 FS/100 ml) further degradation of water quality was noted. TC levels had also shown a small increase (9/100 ml) at the inflow of the St. Mary's River (Stn. 38).

Heterotrophic bacterial concentrations demonstrated a similar pattern to that of June though levels were lower (230/ml) except at the mouth of the Spanish River (Stn. 42: 1,100 to 7,500/ml).

In October to November (Fig. 5), bacteriological water quality remained good over most of the area (1-3 TC, 1 FC and 1 FS/100 ml). At the mouth of the Spanish River (Stn. 42), the water quality continued to deteriorate and sanitary bacterial levels exceeded M.O.E. Criteria (1,100 TC, 110 FC, 44 FS/100 ml).

Only part of the area was surveyed for HB, but concentrations appeared to increase between Blind River and the Spanish River mouth.

...7

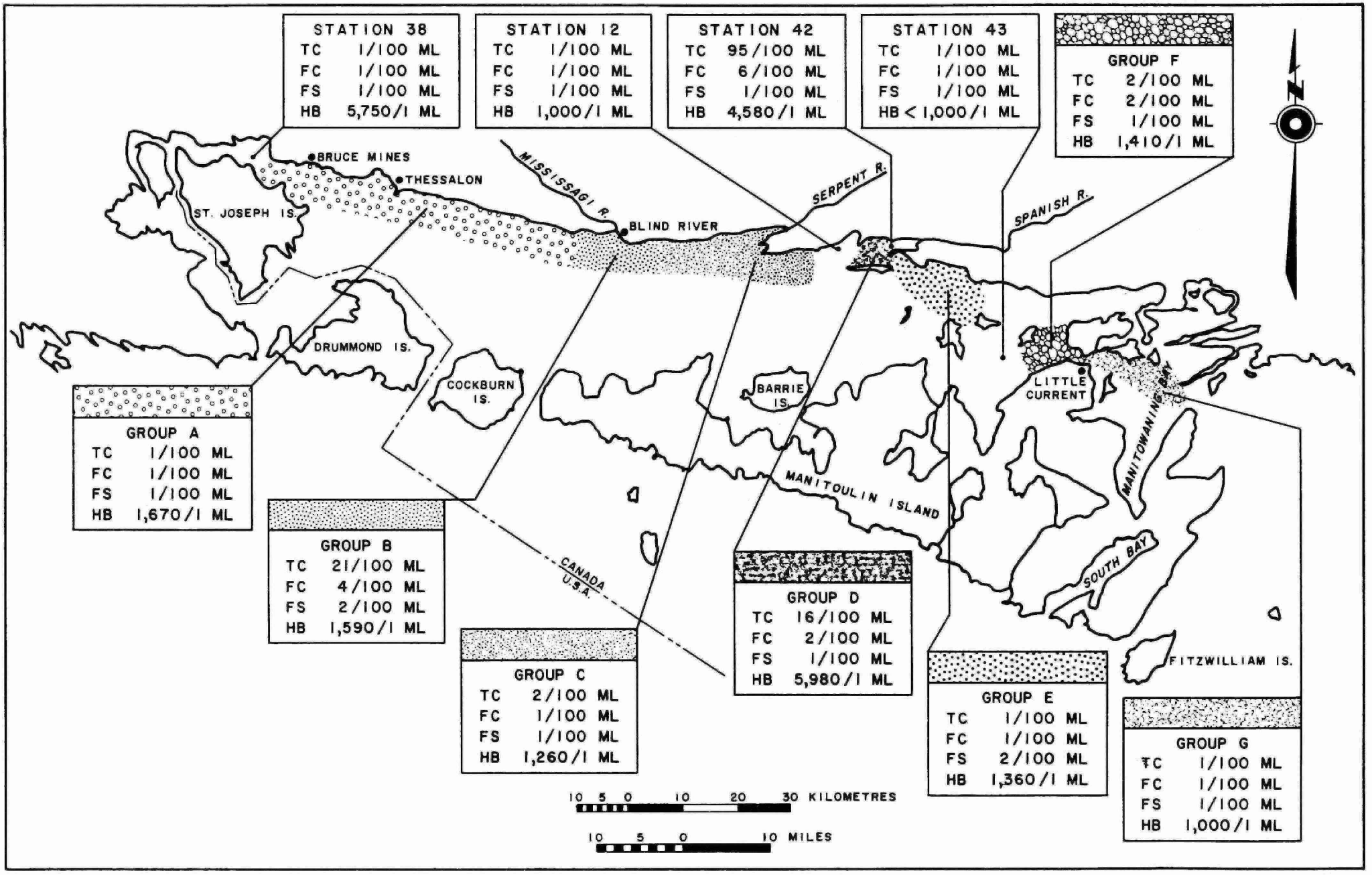


FIGURE 3 - JUNE 1974 NORTH CHANNEL SURVEY

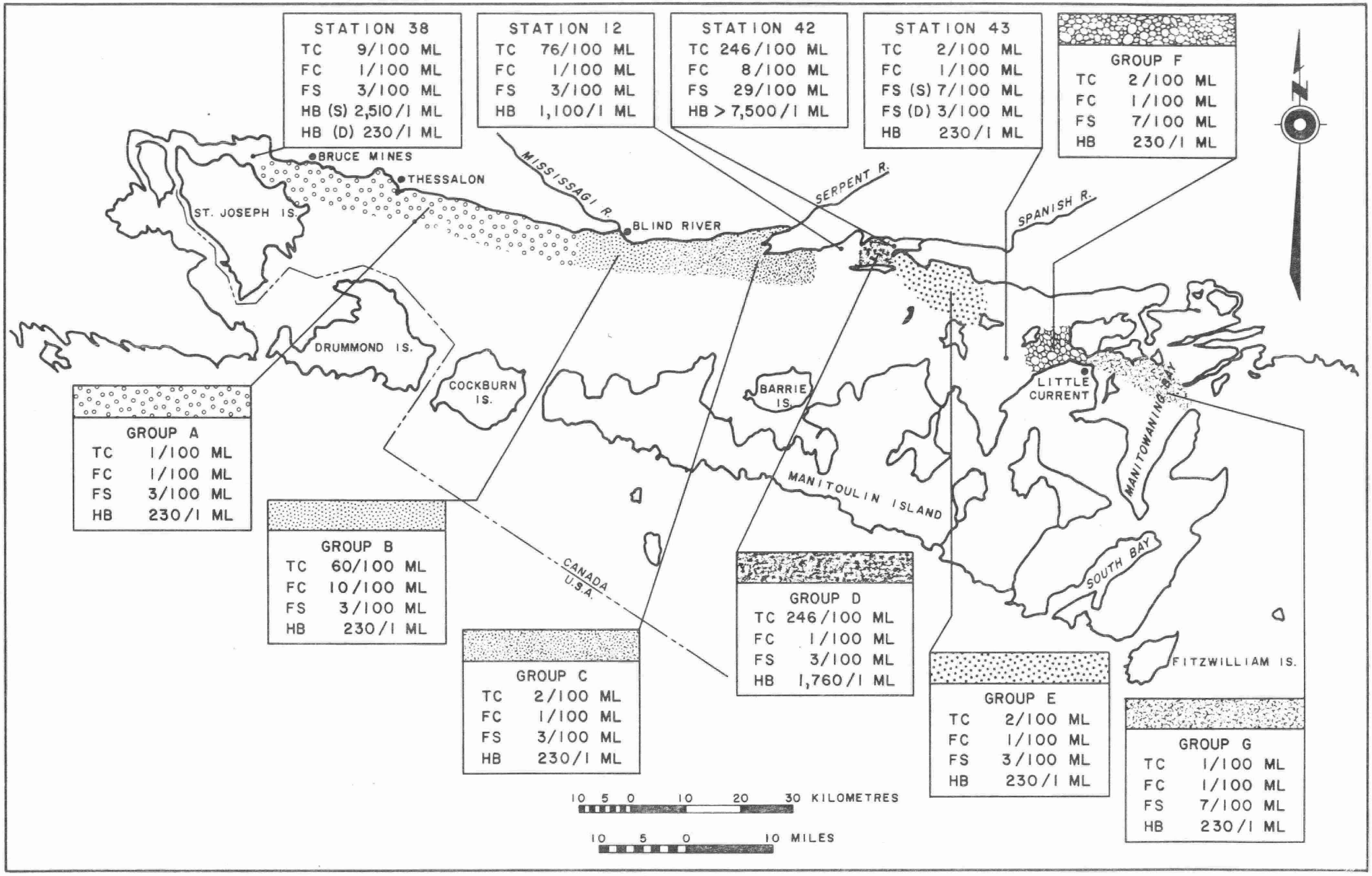


FIGURE 4 - JULY 1974 NORTH CHANNEL SURVEY

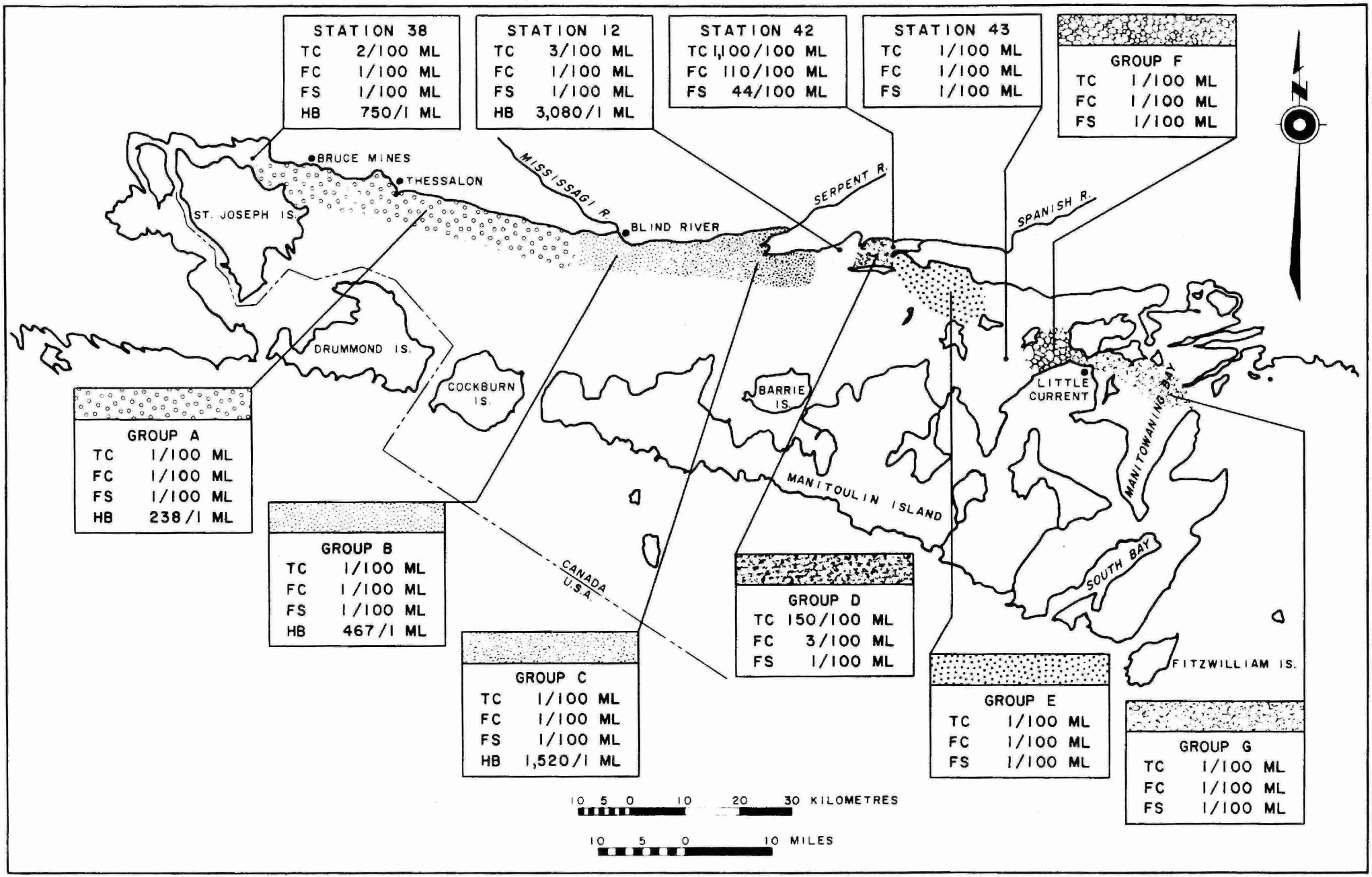


FIGURE 5 - OCTOBER-NOVEMBER 1974 NORTH CHANNEL SURVEY

The background HB levels during the June survey of the North Channel tended to be higher than in the remainder of the nearshore area surveyed. This may be related to the relatively smaller size of the North Channel and nutrient inputs from sources such as the St. Mary's River and the Spanish River.

The elevated bacterial densities at Blind River (June and July) and the mouth of the Spanish River (June, July and October-November) were probably due to improperly treated municipal wastes and general urban runoff. In the case of the Spanish River, this is combined with pulp and paper mill wastes which enter upstream.

The May 1975 surveys of the mouths of the Serpent and Spanish Rivers (4) indicated similar water quality to that found in 1974. The Serpent River area has very low TC, FC and FS concentrations and P. aer. was not isolated. The Spanish River area however had TC and FC densities approaching M.O.E. criteria and P. aer. was isolated from almost all sampling locations. Both areas had high populations of sulphur oxidizing bacteria. The Serpent River, which drains a mining area, had levels from 6,000 to 24,000 per 100 ml and the Spanish River, which receives pulp and paper mill wastes, had levels from 10,000 to 45,000 per 100 ml. The proportion of these sulphur oxidizer concentrations that are due to reduced sulphur compounds being introduced from the Serpent and Spanish Rivers and what proportion is due to natural limnological conditions in this area is not possible to determine without a study of this phenomenon over the entire channel.

Georgian Bay

The survey conducted in Georgian Bay through May and June (Fig. 6 and 7) generally indicated waters of good quality (1-6 TC, 1-2 FC, 1-2 FS/100 ml) with elevated levels at areas located near urban centres and/or sewage treatment plants.

...8

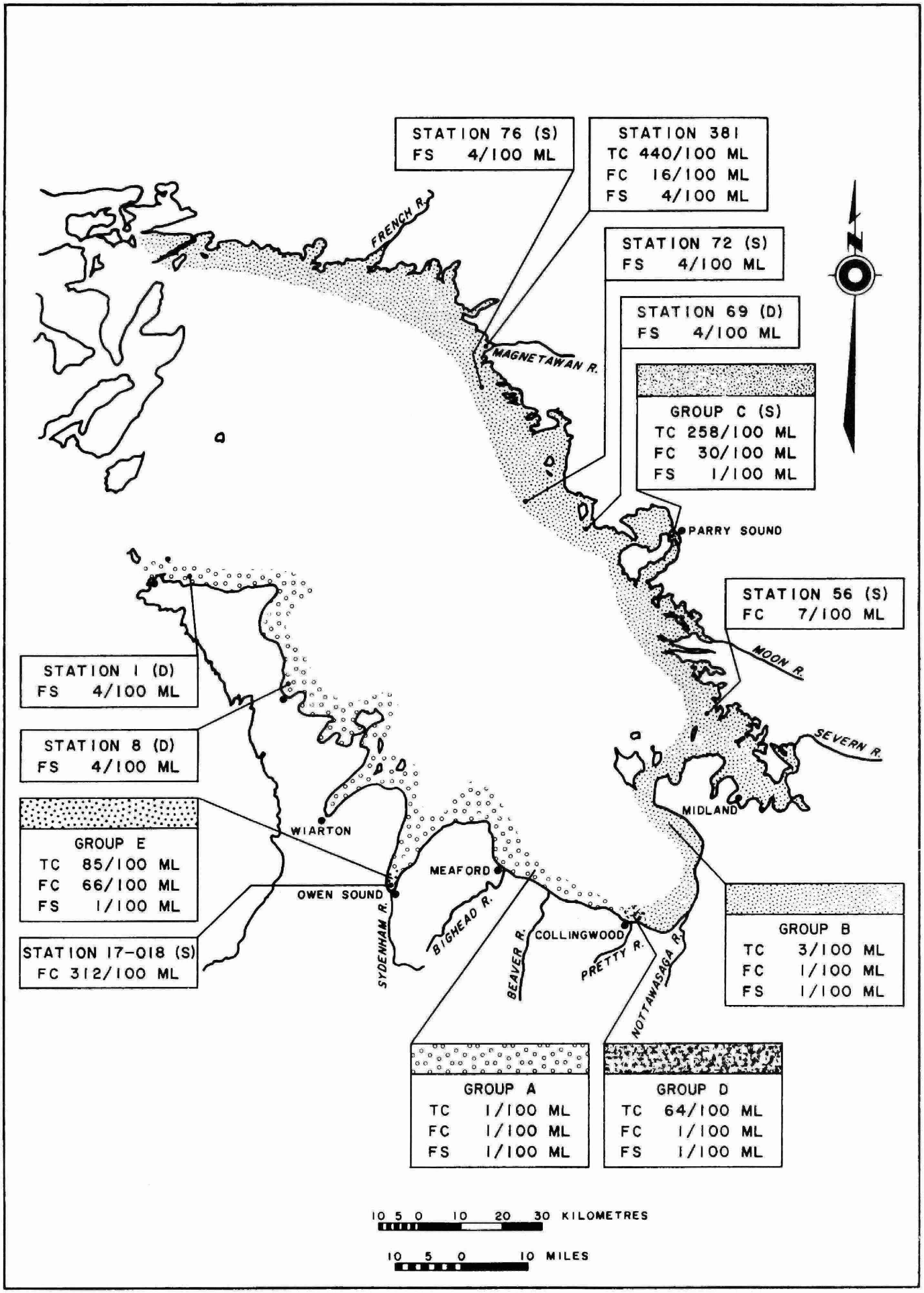


FIGURE 6 - MAY-JUNE 1974 GEORGIAN BAY SURVEY

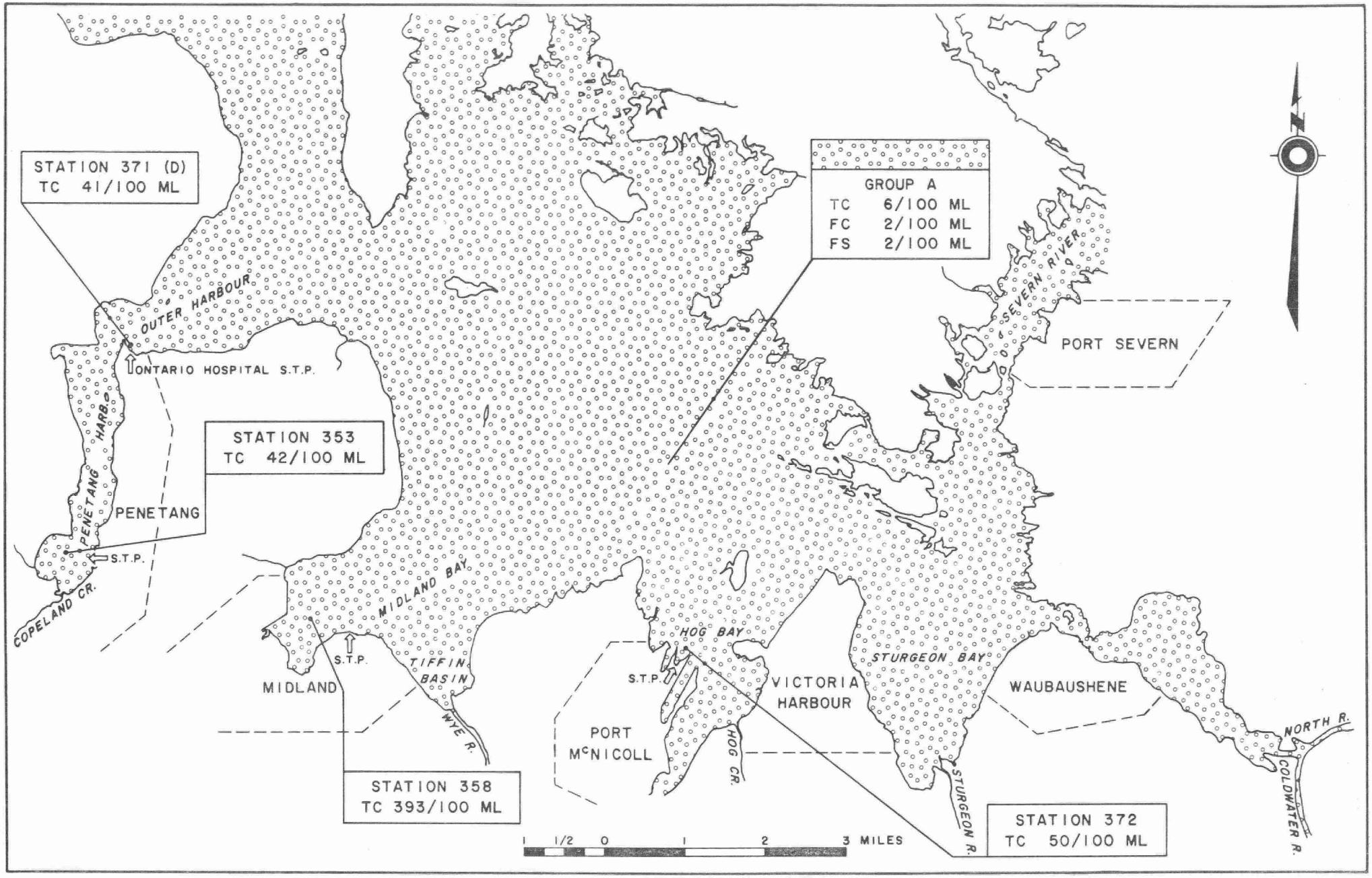


FIGURE 7 - MAY-JUNE 1974 PENETANG-WAUBAUSHENE SURVEY

The waters near Britt (Stn. 381), at the mouth of the Magnetawan River had elevated densities for TC and FC of 440 and 16/100 ml respectively. The surface waters in Parry Sound Harbour (67-S and 68-S) had TC and FC levels of 258 and 30/100 ml. Owen Sound Harbour (17-016, 17-017, 17-018D) had elevated TC and FC levels of 85 and 66/100 ml respectively and the surface waters in one location (Stn. 17-018S) had an FC level of 312/100 ml, which exceeded the M.O.E. criteria for recreational use. In each of the above areas, the FC/FS ratio exceeded 4.0, thus indicating possible human fecal contamination. P. aer. was only isolated in Owen Sound (Group E: 2/100 ml) and Parry Sound (Stn. 67: 1/100 ml), the areas which had the highest FC concentrations in June.

In addition, the Collingwood Harbour waters (17-019, 17-020, 17-021) had TC densities of 64/100 ml. Isolated areas in Penetanguishene Bay (353, 371), Midland Bay (358) and Hog Bay (372) had elevated TC levels (41-393/100 ml) and the surface waters just outside the Penetanguishene-Waubaushene area (56-S) had slightly elevated FC levels (7/100 ml). Waters in three locations along the northwestern shore (Stn. 76-S, 72-S and 69-D) and two locations along the southwestern shore (Stn. 8-D and 1-D) had slightly elevated FS levels (4/100 ml).

The area between Wiarton and Parry Sound was the only one for which HB counts were obtained during the May-June survey (Fig. 8, 9). The HB concentration for most of the Georgian Bay nearshore area fluctuated between 1 and 182/ml and for the Penetanguishene-Waubaushene area were at 482/ml. Owen Sound Harbour (17-016, 17-017, 17-018) had HB levels that exceeded the M.O.E. criteria for public and private water supplies with 4,020/ml and as did the waters near the Midland Bay STP, where levels were recorded at 2,850/ml.

The second survey (Fig. 10 and 11) conducted through August and September, showed little difference from the first survey in the overall water quality. Although a consistency in the grouping of areas with elevated bacterial concentrations was evident, the levels in these areas increased significantly over the levels of the previous survey.

...9

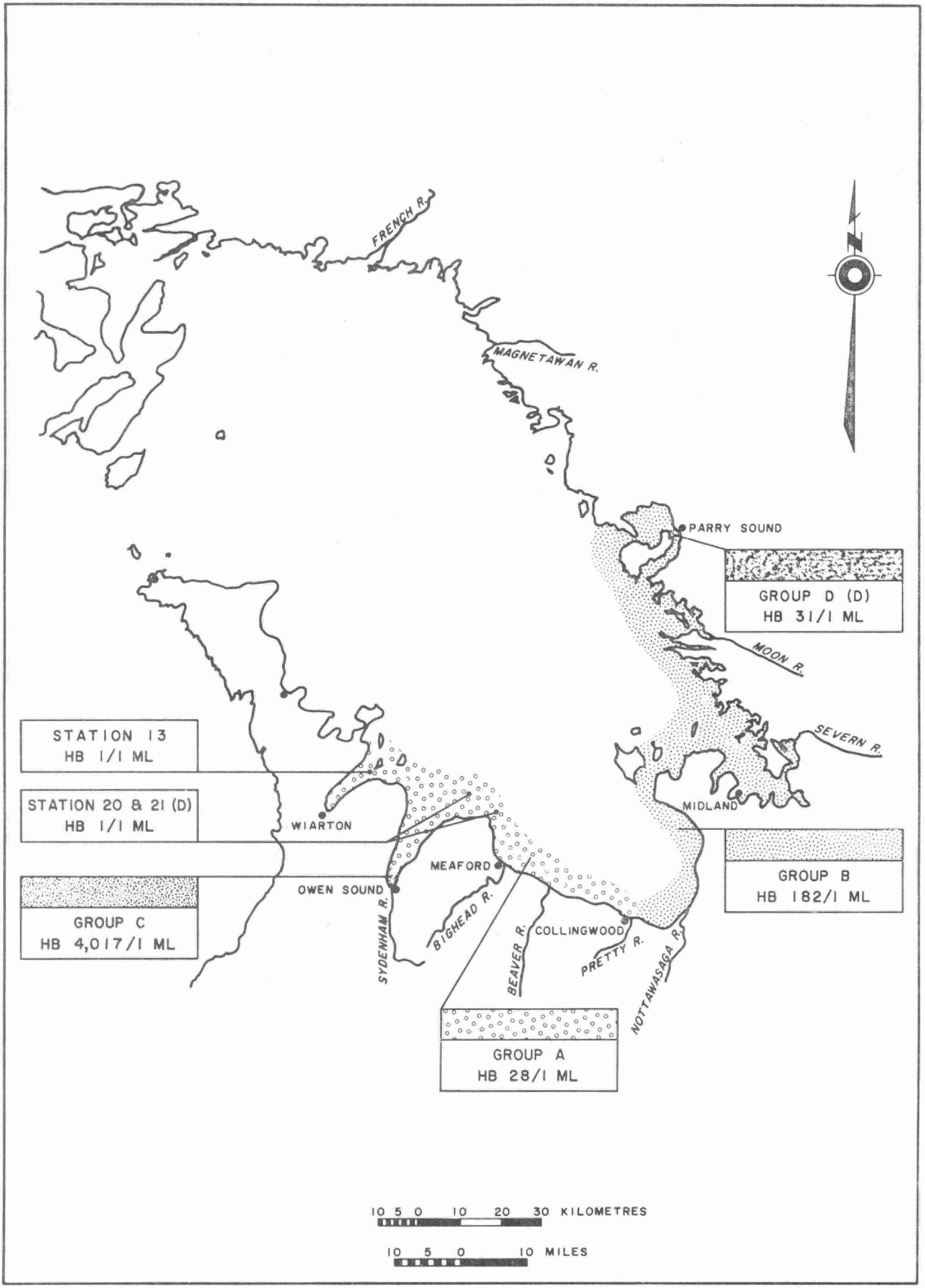


FIGURE 8 - MAY-JUNE 1974 GEORGIAN BAY SURVEY

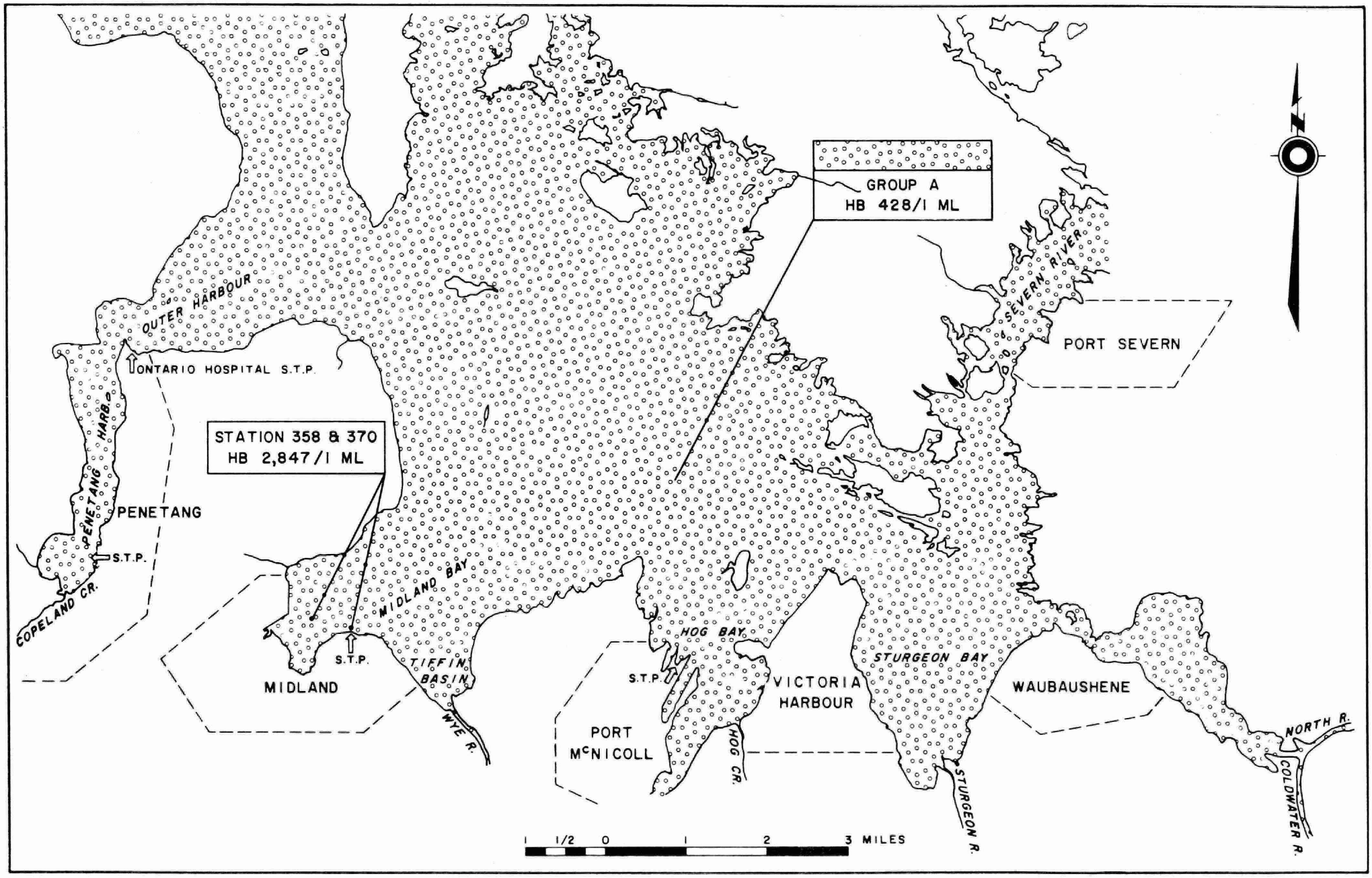


FIGURE 9 - MAY-JUNE 1974 PENETANG-WAUBAUSHENE SURVEY

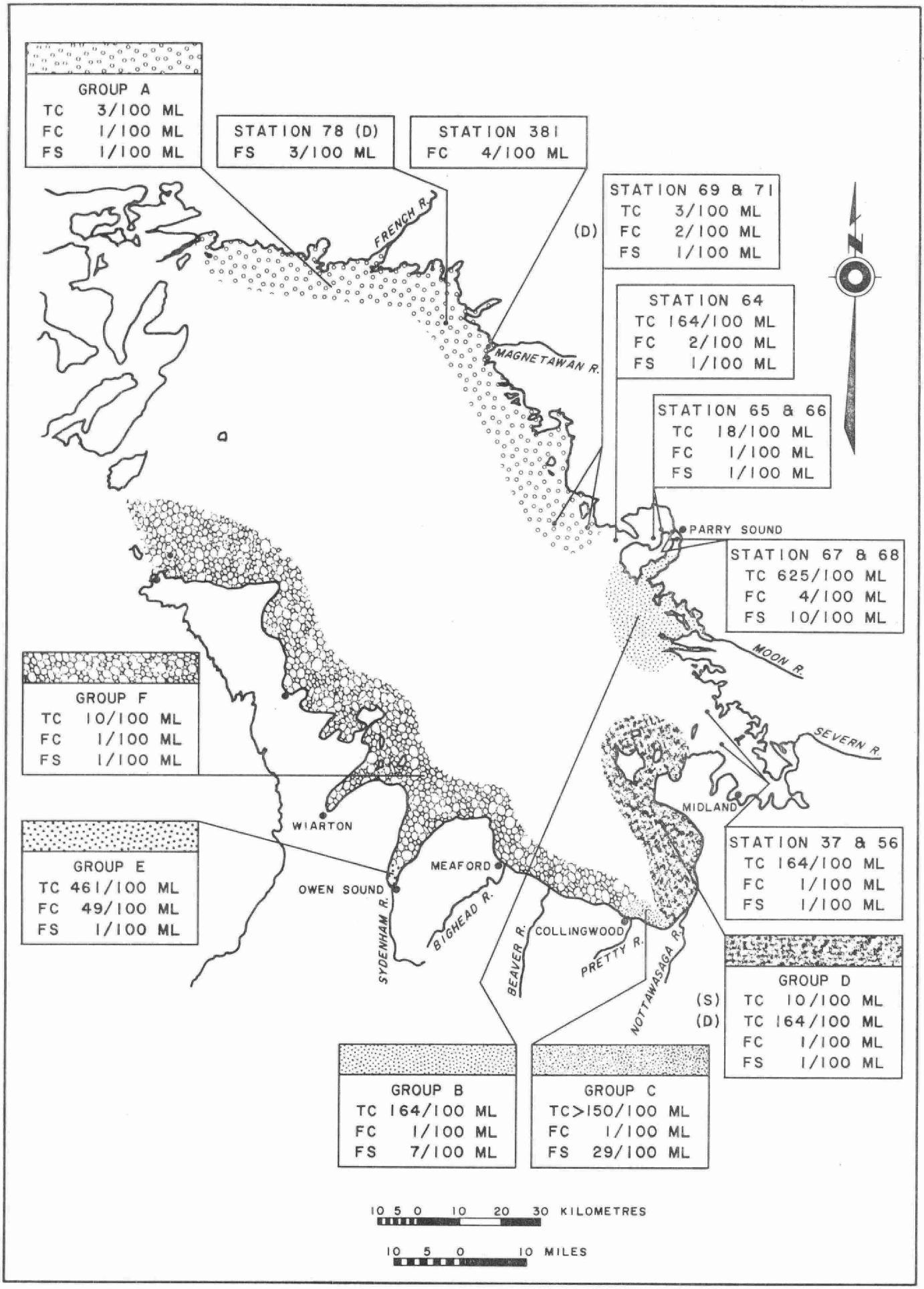


FIGURE 10 - AUGUST-SEPTEMBER 1974 GEORGIAN BAY SURVEY

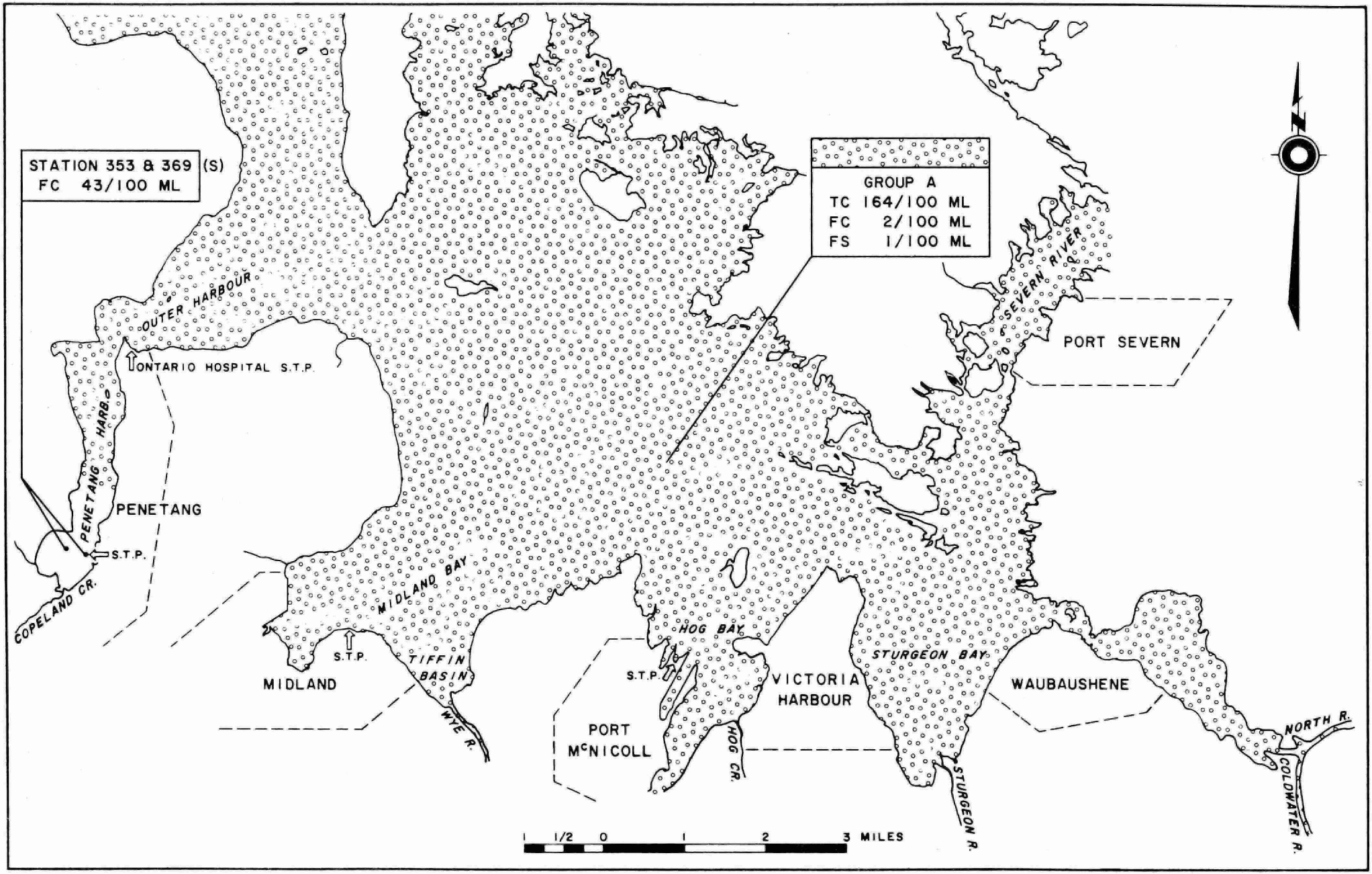


FIGURE 11 - AUGUST-SEPTEMBER 1974 PENETANG-WAUBAUSHENE SURVEY

An unusual situation arose along the eastern shores of Nottawasaga Bay where the TC concentrations varied between the surface and depth waters with 10 TC/100 ml for the surface waters and 164 TC/100 ml for the depth waters. The Penetanguishene-Waubaushene Bay and the area stretching north of this bay to Parry Sound also had TC concentrations of 164/100 ml, a significant increase over the previous survey levels (3/100 ml and 6/100 ml). Surface waters in Parry Sound Harbour (67-S and 68-S) had TC levels of 625/100 ml. In the Owen Sound area (17-016, 17-017, 17-020, 17-021) FC levels were 29/100 ml. This area also had high TC concentrations, however, an exact figure indicating the levels was not available because the bacteriological plates were overgrown. In Collingwood Harbour, the high FS levels in relation to the FC concentrations indicated a non-human source of contamination.

Data for heterotrophic bacterial levels (Fig. 12) was not available for stations between and including Tobermory and Collingwood. The rest of Georgian Bay, where data was obtained, had levels well below M.O.E. criteria for surface water supplies with full treatment (250 HB/ml).

During the November survey, adequate data for statistical analysis was collected only in Parry Sound Harbour. The levels for TC, FC and FS were 218, 54 and 7/100 ml respectively. The ratio of FC to FS levels indicate the source of contamination to be human. Waters at Station "G" exceeded the M.O.E. criteria for recreational use with 211 FC/100 ml. The waters at the mouth of the harbour (64, 65, 66, 69) had significantly lower levels for each of the parameters (Fig. 13). Although the data collected for the area stretching from Little Current to the mouth of Parry Sound Harbour was not adequate for statistical analysis, the individual levels were within the ranges of the levels from the two previous surveys (Fig. 14).

...10

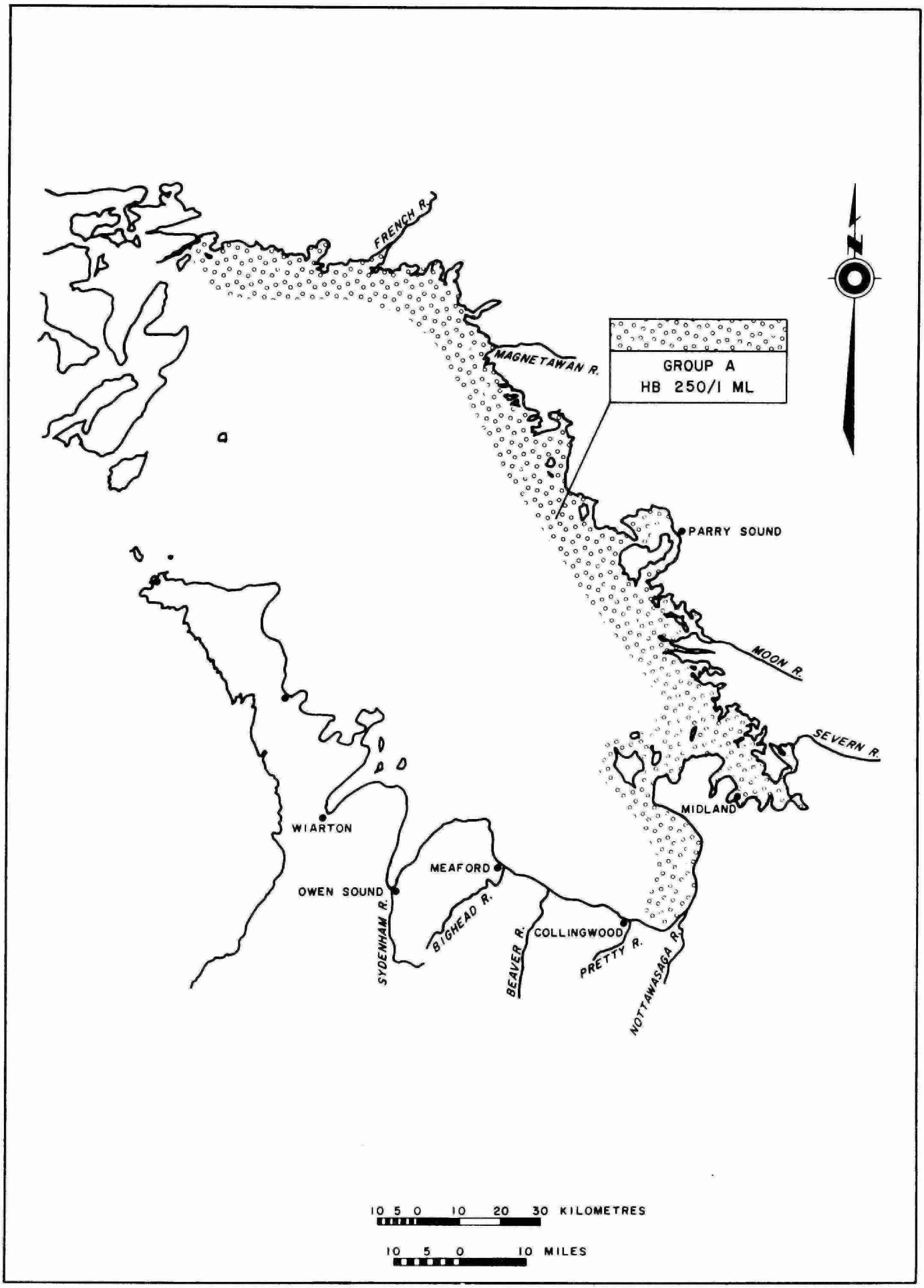


FIGURE 12 - AUGUST-SEPTEMBER 1974 GEORGIAN BAY SURVEY

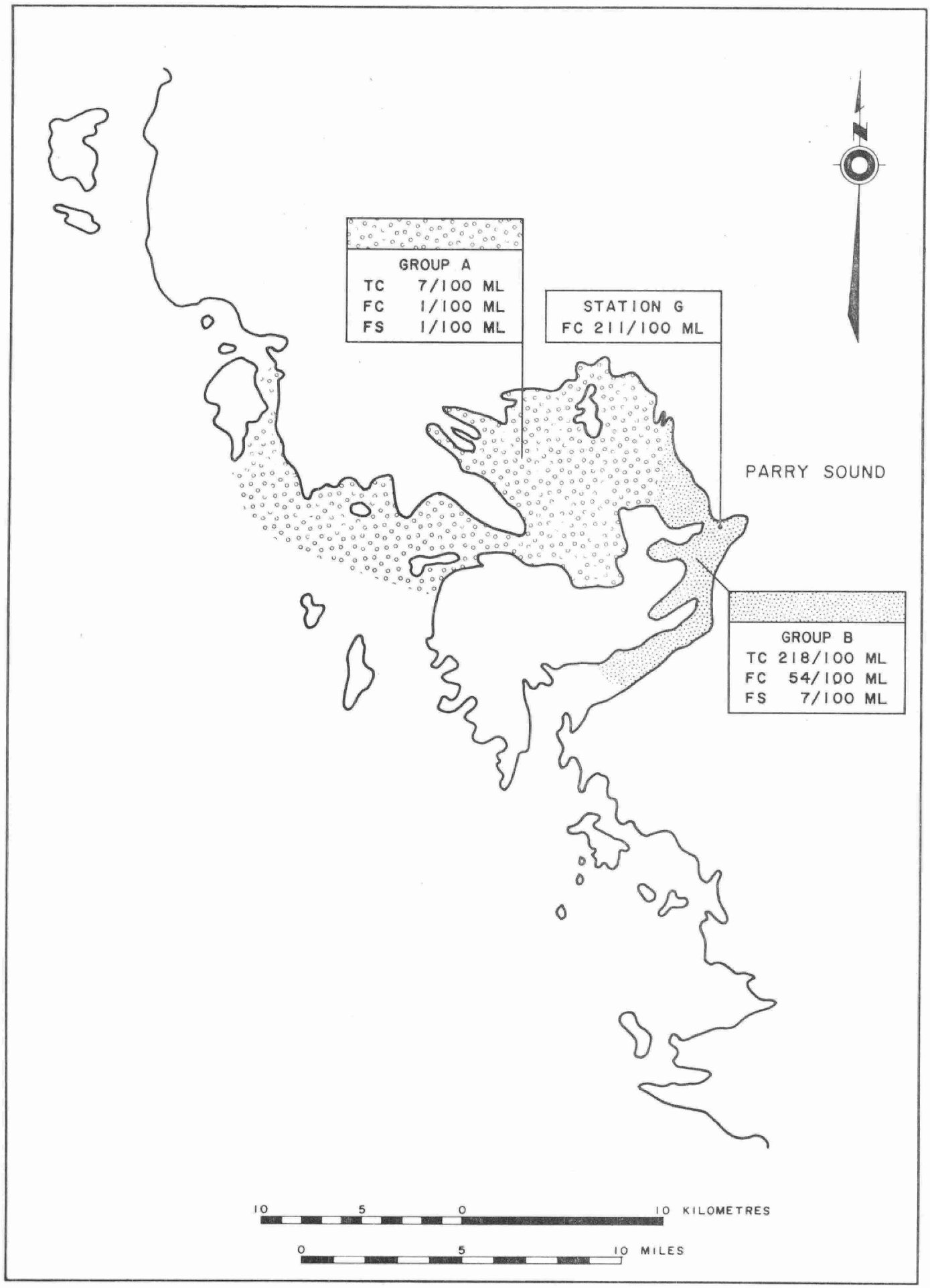


FIGURE 13 - NOVEMBER 1974 PARRY SOUND HARBOUR SURVEY

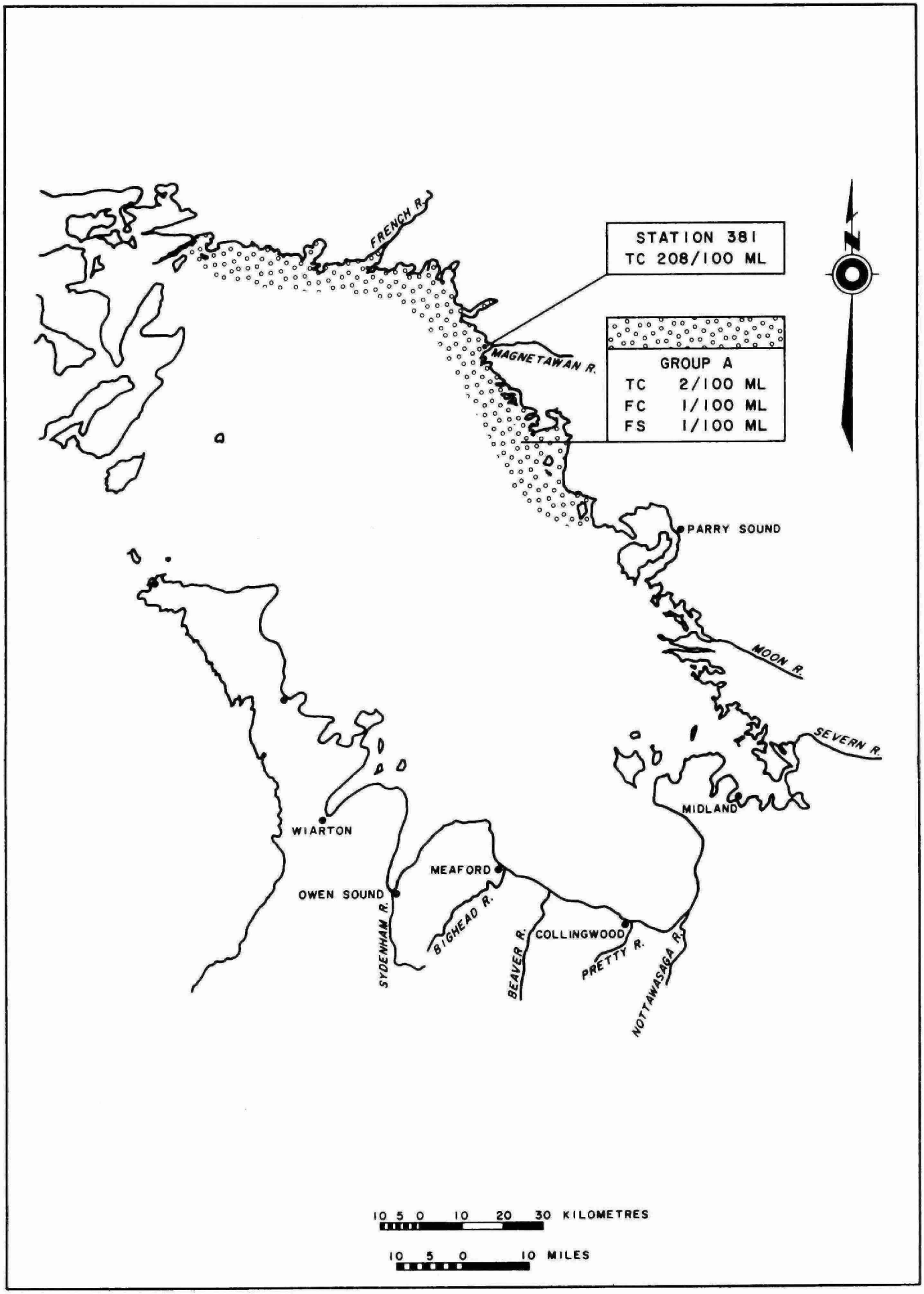


FIGURE 14 - NOVEMBER 1974 GEORGIAN BAY SURVEY

As in the North Channel, higher bacterial densities are associated with areas of human population concentrations and are probably due to insufficiently treated municipal wastes possibly in combination with general urban runoff.

Significant increases in TC levels between the first and second surveys in the Penetanguishene-Waubaushene area and the area from Collingwood to Parry Sound may be due to the major increase in population and recreational activities in these areas during the summer period.

The reason(s) for the difference in TC concentrations between surface and depth waters along the eastern shores of Nottawasaga Bay during the second survey could not be determined. There appeared to be no significant difference in temperature which would seem to rule out thermal stratification.

Lake Huron:

The Lake Huron nearshore surveys consisted of only a sample monitoring run, therefore, sufficient data was not available for statistical analysis. The bacteriological groups presented are based primarily on the survey plan. Areas which appeared to have generally higher bacterial levels were included as separate groups.

During the May survey (Fig. 15), the bacteriological water quality was generally good (1-6 TC, 1 FC & 1-2 FS/100 ml) with higher concentrations in the vicinity of the Southampton-Port Elgin area (Group H: 41 TC & 2 FC/100 ml and Stn. 15-005: 2,400 TC, 48 FC and 12 FS/100 ml), Goderich (Group E: 24 TC, 2 FC & 2 FS/100 ml and Group D: 69 TC, 66 FC & 72 FS/100 ml), Bayfield (Stn. 62: 68 TC & 3 FC/100 ml) Grand Bend (Group B: 14 TC & 2 FS/100 ml). Water quality appeared to be particularly effected in the first two areas.

...11

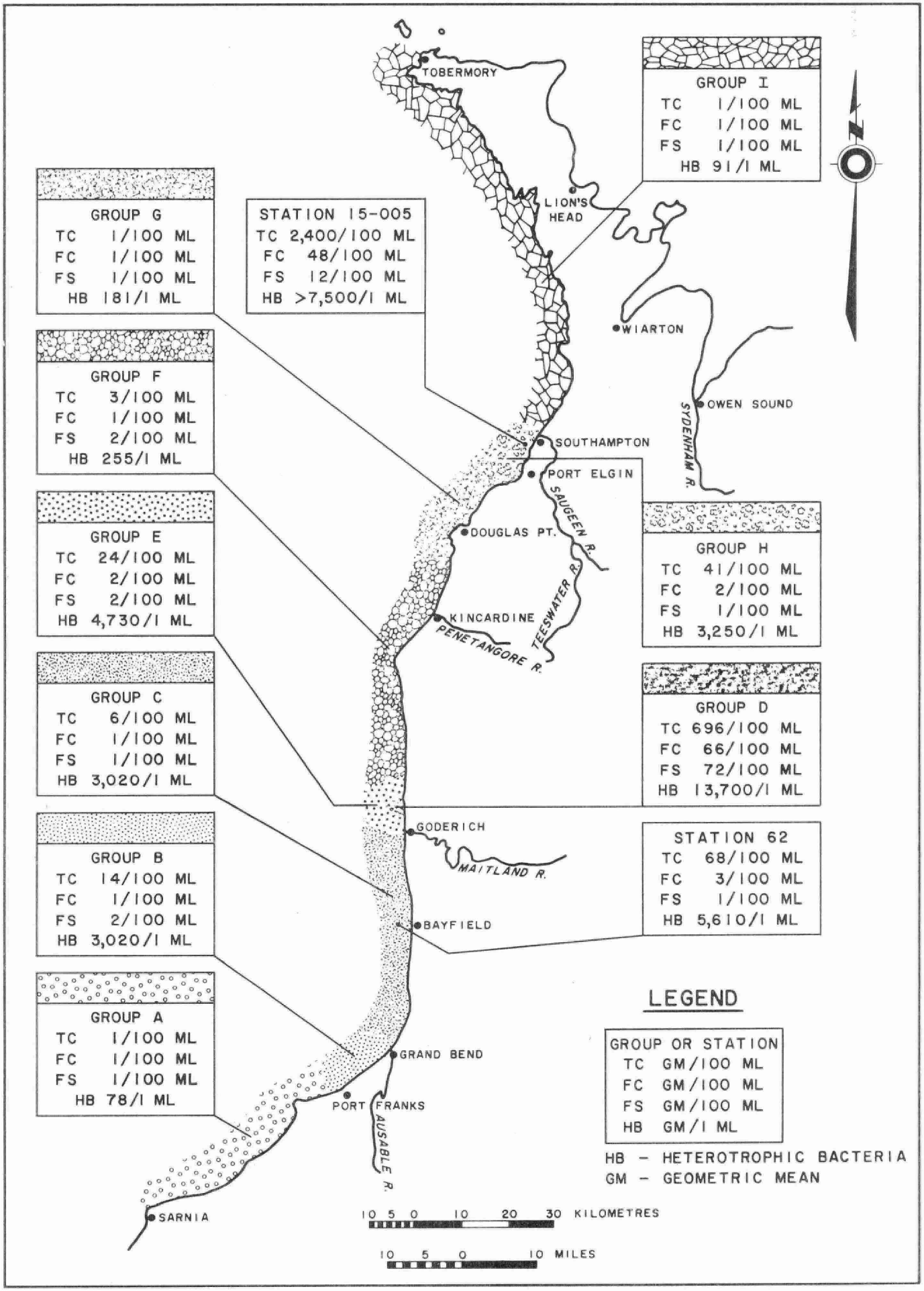


FIGURE 15 - MAY 1974 LAKE HURON NEARSHORE SURVEY

Heterotrophic bacterial levels were elevated in the same areas as the Sanitary Indicator Bacteria. They were also somewhat above background levels in the nearshore waters between Goderich and Grand Bend.

The October survey (Fig. 16) of the southern portion of Lake Huron again indicated good water quality over most of the area (5-14 TC, 1-3 FC & 1-2 FS/100 ml). The waters around Goderich (Group E: 59 TC & 7 FC/100 ml, Group D: 1029 TC, 25 FC & 22 FS/100 ml) once more had the highest bacterial densities with elevated bacterial levels apparent to a lesser degree around Grand Bend.

The April 1975 survey (Fig. 17) demonstrated much the same water quality patterns as the previous surveys. The areas with highest bacterial concentrations were again the mouth of the Saugeen River (Stn. 15-005: 648 TC, 28 FC & 25 FS/100 ml) and Goderich Harbour (Group D: 272 TC, 28 FC & 26 FS/100 ml), and these were also the only areas in which P. aer. was isolated (Stn. 17-001: 8/100 ml and Stn. 15-005: 9/100 ml).

Heterotrophic bacterial densities followed the same pattern as in May 1974 but the densities were higher.

Sanitary Indicator Bacerial levels in the vicinity of the Douglas Point Nuclear Generating Station were at background levels (5), however, sulphur oxidizer levels were found to be in the thousands and tens of thousands per 100 ml both in 1974 and 1975 (6). This compares to 100's or 10's per 100 ml in areas of the nearshore removed from this vicitiy. H_2S in some of the effluent from the generating station entering the aerobic waters of the lake may be responsible for this situation.

...12

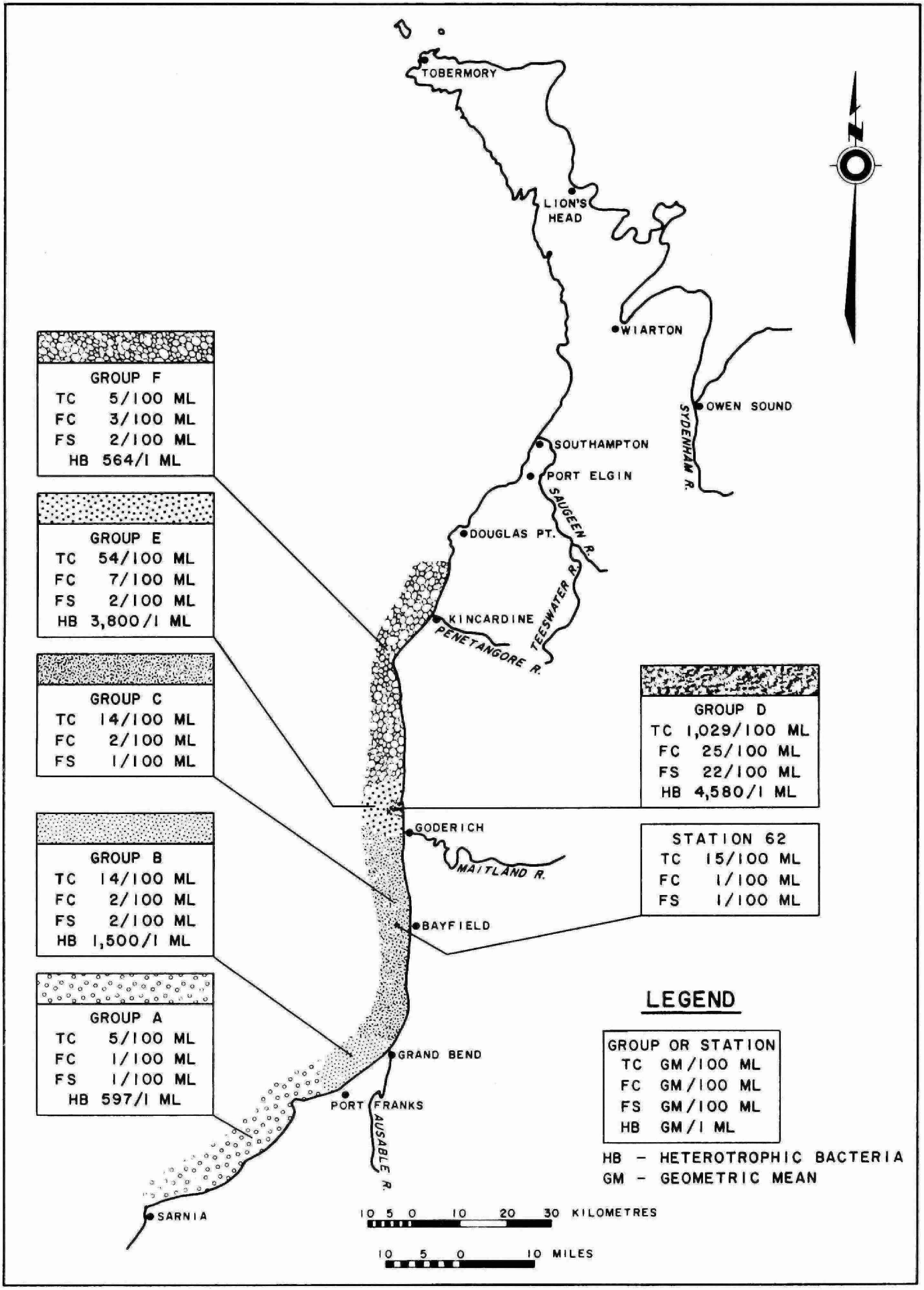


FIGURE 16 - OCTOBER 1974 LAKE HURON NEARSHORE SURVEY

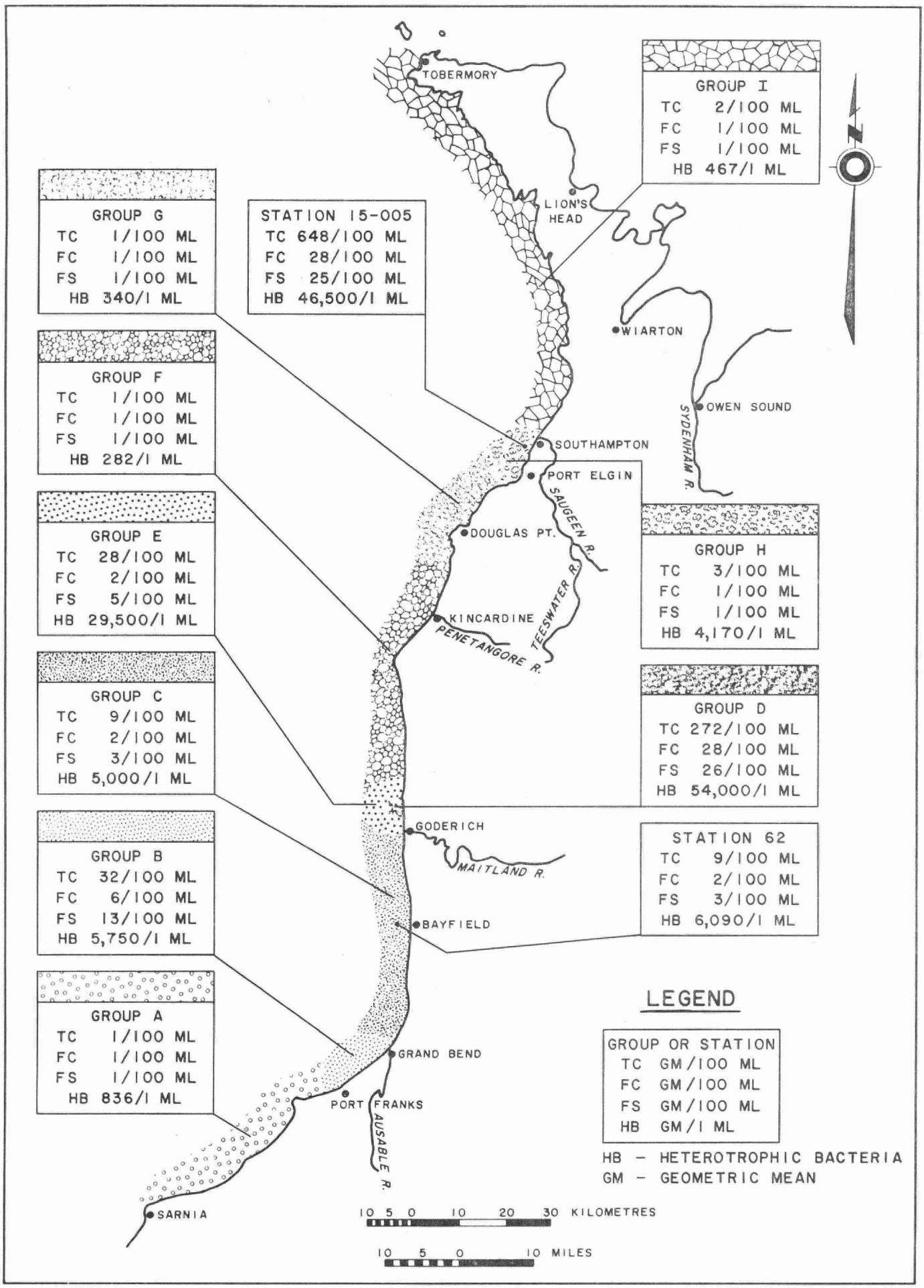


FIGURE 17 - APRIL 1975 LAKE HURON NEARSHORE SURVEY

SUMMARY AND CONCLUSIONS

Most of the Ontario nearshore area of the North Channel, Georgian Bay and Lake Huron is of good water quality, however, exceptions are found in localized areas adjacent to population centres especially in certain harbours and embayments receiving urban drainage, insufficiently treated municipal wastes and/or industrial wastes.

The studies presented in this report did indicate areas with problems or developing problems, however, they were insufficient to establish the areas of impact and influence of the various sources of pollution. If this is to be done, particularly if abatement programs are to be initiated, then more efficient and effective survey designs, such as the zonal grid sampling approach (7), should be utilized in these areas. In conjunction with such studies, an intelligent choice of parameters relating to the problems being studied must be made, for example, Pseudomonas aeruginosa and Fecal Coliforms are of value as point source indicators of inadequately treated fecal wastes, and sulphur cycle bacteria are useful in the study of certain industrial wastes such as pulp and paper mill effluents.

It is also evident from these studies that most of the nearshore waters, including a number of the areas affected by various forms of pollution, have bacterial densities below current M.O.E. and I.J.C. criteria. Thus, if the water quality of this area is to be preserved, more restrictive criteria must be applied.

Clean water areas and degraded areas with bacterial concentrations below current criteria should have criteria based on current bacterial levels. In the first case to preserve the excellent water quality already existing and in the second case to prevent further degradation until appropriate measures can be taken.

Those areas where bacterial levels are currently high and approach or exceed current criteria should receive priority in any abatement programs.

...13

APPENDIX I

Foot and Taylor Agar (Modified)

Peptone	3.0 g
K_2HPO_4	0.2 g
$MgSO_2$	0.05 g
$FeCl_3$	trace
Soluble Casein	0.5 g
Agar	20 g
DH_20	1000 ml
pH 7.2	Autoclave 15 min/15 psi

...14

BIBLIOGRAPHY

1. Standard Methhods for the examination of Water and Wastewater, 13th Edition. 1971. Edited by M.J. Tarus, A.E. Greenberg, R.D. Haok and M.C. Rand. APHA, AWWA, WPCF. pp. 635-693.

2. Levin, M.A. and Cabelli, V.J. 1972. Membrane filter techniques for enumeration of Pseudomonas aeruginosa.
   Appl. Microbiol. 24, 864-870.

3. Geldreich, E.E. and Kenner, B.A. 1969. Concepts of fecal streptococci in stream pollution.
   Journal W.P.C.F. 41, R336-R352.

4. The Bacteriological Water Quality at the Mouths of the Serpent and Spanish Rivers, 1975 Survey.
   Ministry of the Environment Laboratory Report - to be published.

5. The Bacteriological Water Quality in the vicinity of the Douglas Point Nuclear Generating station, 1974 Survey.
   Ministry of the Environment Laboratory report - to be published.

6. Unpublished data - Ministry of the Environment, London Regional Laboratory.

7. Rao, S.S., Rokosh, D.A. and Jurkovic, A.A. 1975. Influence of a point source pulp mill effluent discharge on the nearshore bacterial communities in Lake Superior.
   Presented at the second ICMSE conference on the Great Lakes, Argonne National Laboratory, Argonne, Ill. March 25-27.

A BACTERIOLOGICAL STUDY OF THE DOUGLAS POINT AREA OF LAKE HURON, 1973, 1974 AND 1975.

PATRICIA BOLTON

MICHAEL YOUNG

GREAT LAKES UNIT

MICROBIOLOGY SECTION

LABORATORY SERVICES BRANCH

MINISTRY OF THE ENVIRONMENT

MARCH 1978.

TABLE OF CONTENTS

LIST OF FIGURES

ABSTRACT

Bacteriological surveys of Lake Huron in the vicinity of the Huron and Douglas Point nuclear generating stations were conducted in 1973, 1974 and 1975 to monitor water quality and assess the effect of the heavy water plant effluent on the Douglas Point area of the lake. The results showed that, at the time of the survey, levels of sanitary indicator bacteria were well within the acceptable limits. However, the distribution of sulphur oxidizers would indicate that the Douglas Point generating station effluent could be a source of reduced sulphur compounds.

A Bacteriological Study of the Douglas Point Area of Lake Huron

Introduction

Monitoring surveys of water quality in the vicinity of the Huron and Douglas Point generating stations complex have been conducted by the Ontario Ministry of the Environment (MOE) since 1967 to determine the environmental impact of the operation of the Douglas Point Generating Stations and the Bruce Heavy Water Plant and to provide background information prior to the start up of the Bruce Generating Station and planned additional generating facilities.

In addition to this monitoring, a more intensive study of the area was carried out in 1974 to assess the effect of the existing, heavy water plant (thermal) discharge at the Douglas Point area of Lake Huron.

Bacteriological studies were incorporated into the ongoing monitoring programme in 1973. This report discusses the results of the 1973, 1974 and 1975 bacteriological surveys.

Methods

1. Field Procedure

Nine stations, (113-117, 121, 122, 123, 364) were sampled on July 6, 7 and 9, 1973 and again on August 28, 29 and 31, 1973.

On May 17, 18 and 19, 1974, samples from the same nine stations plus station 125 were analyzed. Periodic samples were taken at eight stations (7, 18, 12, 16, 17, 18, 20 and 1 mile) in the same area on June 28, August 1, October 1 and

October 24, 1974. (Fig. 1).

The 1975 surveys combined much of the previous two years' sampling. On April 27, 28 and 29, samples from the nine stations in the 1973 surveys were collected and five new stations (368-373) were added. On May 16 and June 26, sampling was carried out at the eight stations from the periodic sampling in 1974. Surface and depth samples were collected at each station. Surface samples were taken at 1.5 metres below the surface of the lake in sterile 175 ml glass bottles. All depth samples were collected two metres above bottom in sterile, evacuated rubber bulbs. All samples were immediately put on ice and transported to the southwestern regional M.O.E. laboratory in London for analysis.

2. Laboratory Procedures

All samples were analyzed from three types of sanitary indicator bacteria Total coliform (TC), fecal coliform (FC) and fecal streptococcus (FS) to determine if any fecal contamination existed. In additon, for the May 1974 and the April and May 1975 surveys a determination of the heterotrophic bacterial population (HB) was made. Pseudomonas aeruginosa (P.aer.) was used as a survey parameter for the April 1975 survey.

Analysis for the sulphur oxidizing (autotrophic) bacteria T.thioparus was included in the periodic surveys in 1974 (June through October) and in all the 1975 surveys.

A description of the methods used to determine TC, FC, FS, P.aer. and HB levels may be found in the Penetang-Waubaushene 1974 report (1).

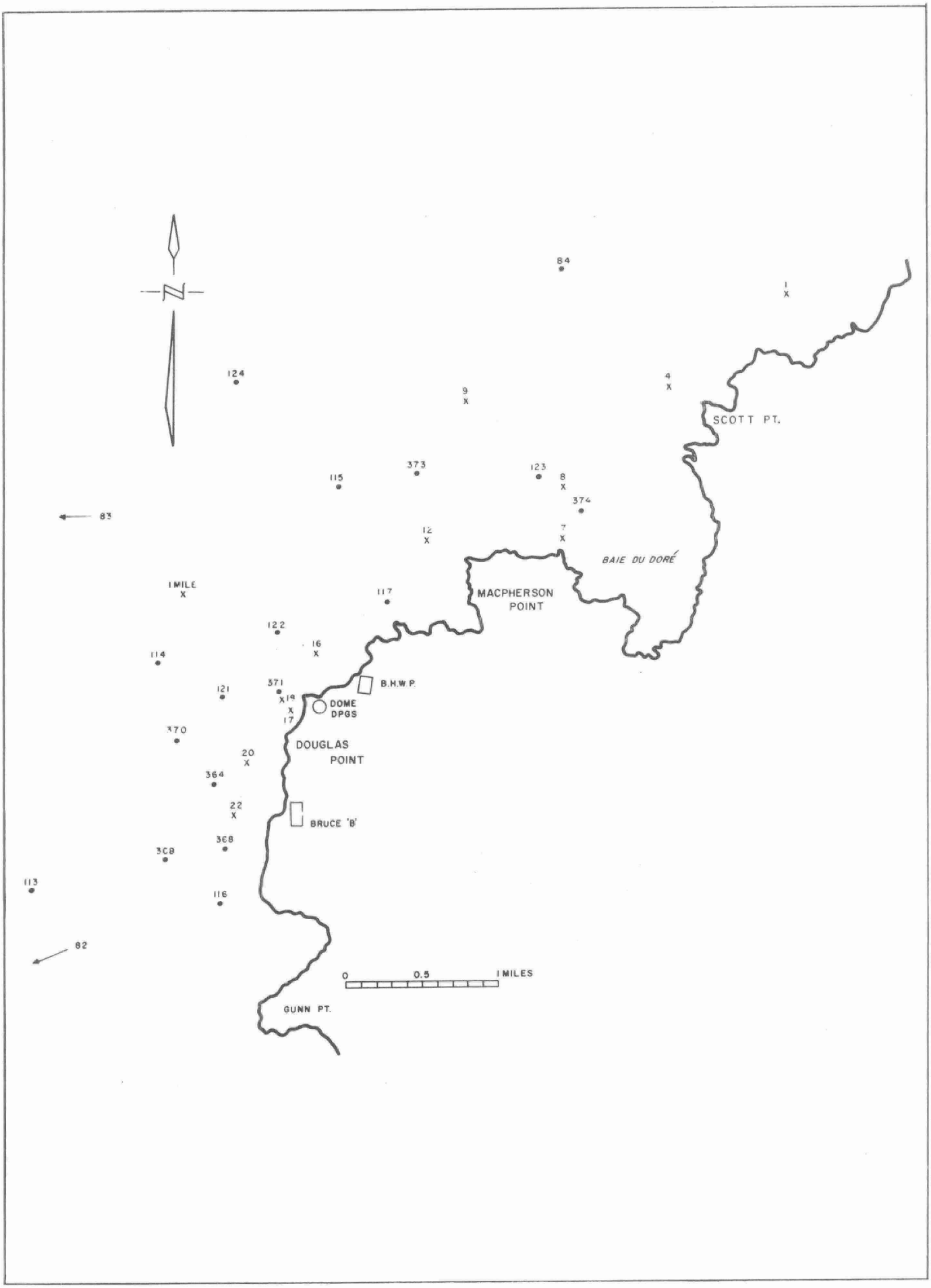


FIG. 1 LOCATION OF SAMPLING STATIONS 1973, 1974, & 1975 DOUGLAS POINT SURVEYS.

The autotrophic bacterial analysis was instituted to determine the levels of sulphur-oxidizing bacteria, primarily Thiobacillus thioparus. These bacteria are generally found in greater numbers in water containing reduced sulphur compounds from industrial effluents. Analysis was done using a three-dilution, triplicate tube, most probable number (MPN) technique according to Standard Methods (14th edition) (2). The medium used was a modified Postgate's Thioparus broth (see Appendix A) (3). Incubation was for four weeks at 20^0 C and counts were recorded as number of organisms per 100 ml. During the 1974 surveys, a positive reaction was determined by the addition of barium chloride solution to the tube and observation of a white (barium sulphate) precipitate. In 1975, a positive reaction was determined by a starch-iodine titration of the thiosulphate (4).

3. Statistical Analysis Methods

The statistical methods used to analyze the TC, FC, FS, P.aer. and HB data were the same as those outlined in the Penetang-Waubaushene 1974 report (1).

The amount of data available for T. thioparus in 1974 and 1975 was insufficient for statistical analysis. Therefore, the data was pooled according to date and geographical location. Four time periods were established by grouping the one day surveys in pairs (June 28 & August 1, 1974, October 4 & October 23, 1974 and May 16 & June 26, 1975) and letting the three day survey (April 1975) form the fourth group. For each time period, the stations were placed in groups that formed concentric circles with increasing distance from the Douglas Point Generating Station outfall (Fig. 3). The boundaries of the groups were arbitrarily chosen so that five areas were delineated,

each of which included stations from both the 1974 and 1975 surveys. The geometric mean of each area was calculated for the four time periods. A number of stations had bacterial concentrations less than expected and no reliable counts were obtained which further reduced the amount of data available.

Criteria

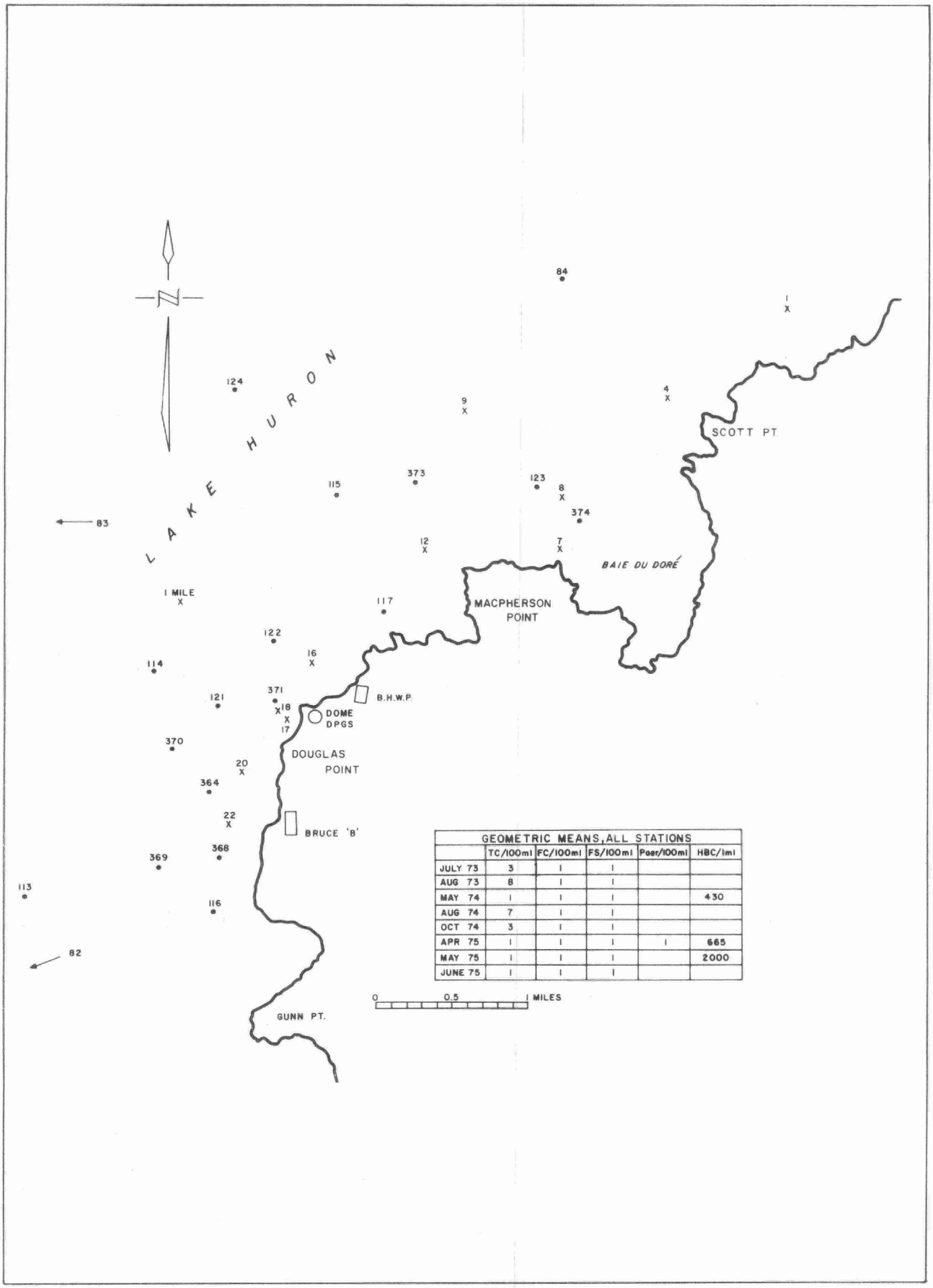
The Ministry of the Environment Bacterial Criteria and/or comments about TC, FC, FS, P.aer. and heterotrophic bacteria may be found in the Penetang-Waubaushene 1974 report (1).

High numbers of T. thioparus indicates the presence of reduced sulphur compounds in water. However, since this bacterium is not an established parameter, criteria defining acceptable levels have not been established.

Results and Discussion

The Douglas Point area of Lake Huron displayed good water quality during the 1973 surveys. Statistical analysis of the data showed a significant difference in the total coliform levels between July and August although the actual concentrations did not increase appreciably (from 3 TC/100 ml in July to 8 TC/100 ml in August). The fecal coliform and fecal streptococcus densities showed no significant variation between the July and August surveys (geometric mean density of 1/100 ml for both parameters).

The water quality in May 1974 remained good having TC, FC and FS densities of 1/100 ml and an heterotrophic bacterial concentration of 430/ml (Fig.2). These counts were not significantly different from the Lake Huron near shore bacterial levels determined during the same period(5).



GEOMETRIC MEANS, ALL STATIONS

	TC/100ml	FC/100ml	FS/100ml	Pseu/100ml	HBC/1ml
JULY 73	3	1	1		
AUG 73	8	1	1		
MAY 74	1	1	1		430
AUG 74	7	1	1		
OCT 74	3	1	1		
APR 75	1	1	1	1	665
MAY 75	1	1	1		2000
JUNE 75	1	1	1		

FIG. 2 BACTERIAL LEVELS AT DOUGLAS POINT 1973, 1974, 1975.

In April, May and June of 1975, the TC, FC, FS and P.aer. levels were 1/100 ml or less and the HB rose from 665/ml in April to 2000/ml in May. These results indicate that there was no fecal pollution and probably no nutrient enrichment at the time.

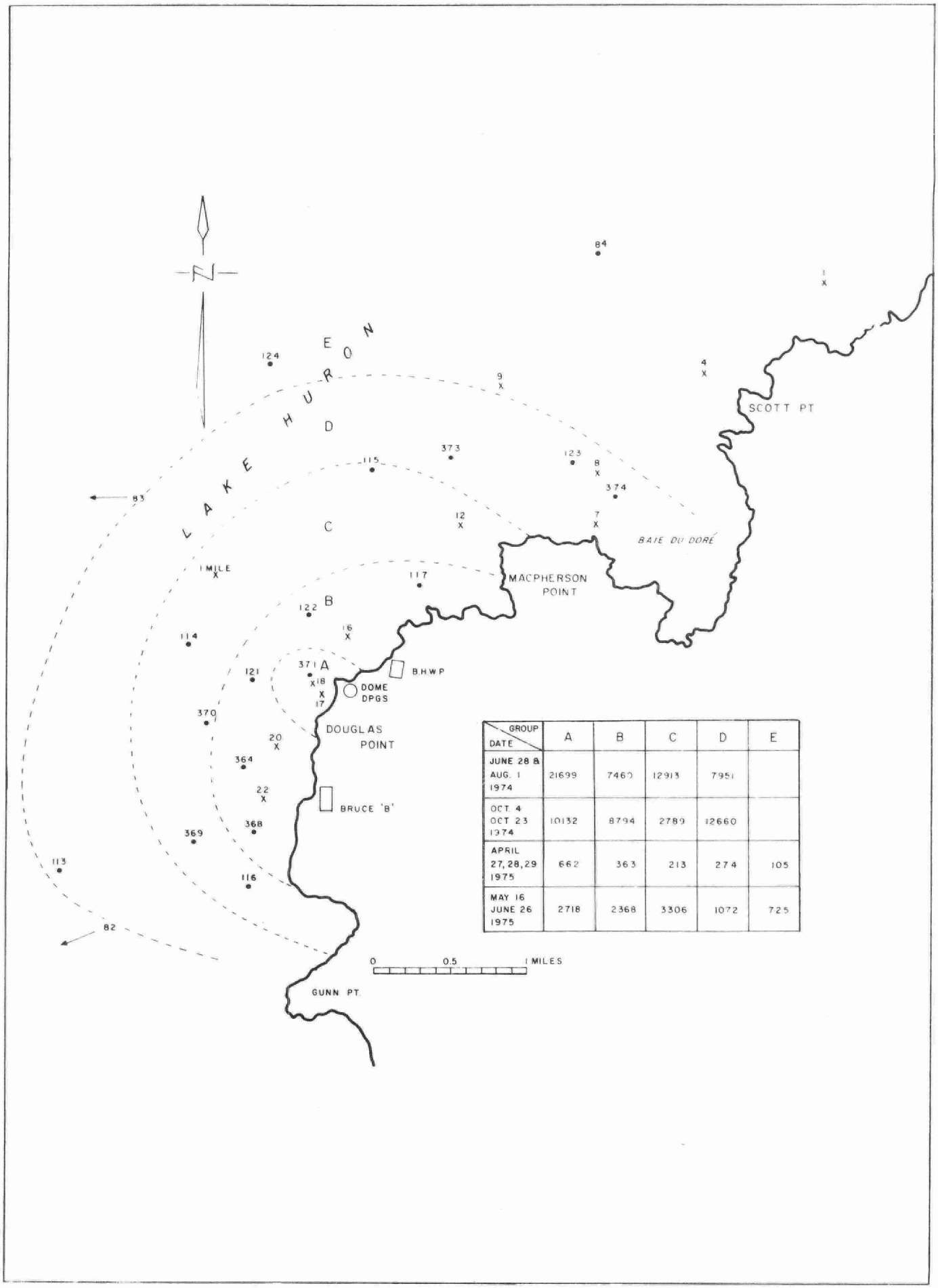
Calculations of the means of the pooled data showed that the level of T. thioparus appeared to follow two general trends. The overall level of the bacteria in the survey area increased during the June and August surveys in 1974. Levels had decreased by Octoer of 1974 and in April of 1975 the population density was the lowest determined. The surveys during the summer of 1975 indicated that, although the concentration of T. thioparus had increased since the spring survey, the level was not as high as the previous summer. This pattern was similar for the available heterotrophic bacterial data and was most likely due to warmer water temperatures causing generally increased biological activity when nutrients were available. The second trend exhibited was a tendency for the densities of T.thioparus to decrease as distance from the source increased. Counts of over 20,000 per 100 ml were obtained in the immediate vicinity of the Douglas Point Generating Station outfall in the summer of 1974. The stations furthest from the point source had a mean of less than 8000 per 100 ml during the same period. In the 1975 surveys, the same dilution effect was noticeable.

There were occasions when unusually high values were determined away from the source, however, these were probably not accurate reflections of the water quality. They generally occured when little data was available for the area and therefore, a single high count had a greater effect on the computations.

The actual number of T. thioparus were lower in 1975 than 1974 (Fig. 3) but were still much higher than other nearshore locations not in the survey area. The high concentrations of T. thioparus in the vicinity of Douglas Point would indicate that the effluent from the generating stations contains a higher level of reduced sulphur compounds (possibly H_2S) than the receiving water and other parts of the lake.

Summary and Conclusions

The water quality in the area of Douglas Point is generally good. The generating stations and the heavy water plant do not appear to be exerting an appreciable impact on the levels of sanitary indicator bacteria. However, the distribution of T. thioparus would indicate that the effluent from the Douglas Point generating station could be a source of reduced sulphur compounds. Continued study of this area, particularly of the sulphur cycle bacteria, would be of value in order to provide a more extensive data base. This would facilitate a more representative interpretation of the bacterial levels. In addition, criteria for acceptable levels of industry-related bacteria might be established to prevent degradation of the water quality.



GROUP / DATE	A	B	C	D	E
JUNE 28 & AUG. 1 1974	21699	7460	12913	7951	
OCT. 4 OCT. 23 1974	10132	8794	2789	12660	
APRIL 27, 28, 29 1975	662	363	213	274	105
MAY 16 JUNE 26 1975	2718	2368	3306	1072	725

FIG. 3 DISTRIBUTION OF T. THIOPARUS AT DOUGLAS POINT, 1974 & 1975.

REFERENCES

1. Young, M. December 1977. A Bacteriological Study of the Penetanguishene-Waubaushene Area of Georgian Bay. Ministry of the Environment, Microbiology Section.

2. Standard Methods for the Examination of Wastewater. 1975. A.W.W.A., W.P.C.F. 14th Edition.

3. Thompson, F. 1969. Elliot Lake Report-Some Implications of Autotrophic Sulfur and Iron Bacteria in Water Pollution by Uranium Mill Trailing Wastes in the Elliot Lake Area. Ontario Water Resources Commission. Bacteriology Section.

4. Jenkins, G., Young, M. December 1977. Bacteriological Survey of the Serpent River 1975. Ministry of the Environment, Microbiology Section.

5. Young, M., Toth, A., Janurst, S and Jenkins, G. December 1977. A Bacteriological Study of the Ontario Nearshore Areas of Lake Huron. Ministry of the Environment, Microbiology Section.

APPENDIX

Media Formulations

(1) Postgate's Medium

(Thioparus Broth)

Ingredients	Amount/litre
Sodium Thiosulphate ($Na_2S_2O_3.5H_2O$)	5.0 g
Ammonium Chloride (NH_4Cl)	1.0 g
Potassium Phosphate (KH_2PO_4)	3.0 g
Calcium Chloride ($CaCl_2.2H_2O$)	0.33 g
Magnesium Sulphate ($MgSO_4.7H_2O$)	1.0 g
Trace Element Solution	1.0 ml
Distilled Water	1000 ml

(2) Trace Element Solution

Solution 1

EDTA (disodium magnesium salt)	6.19 g
dH_2O	60 ml

Solution 2

Ferrous sulphate ($FeSO_4.7H_2O$)	0.50 g
Zinc sulphate ($ZnSO_4.7H_2O$)	0.88 g
Manganese chloride ($MnCl_2.4H_2O$)	0.14 g
dH_2O	10 ml

Solution 3

Ammonium Molybdate $(NH_4)_6Mo_7O_{24}.4H_2O$	0.09 g
Cupric sulphate ($CuSO_4$)	0.10 g
Cobalt chloride ($CoCl_2.6H_2O$)	0.04 g
dH_2O	10 ml

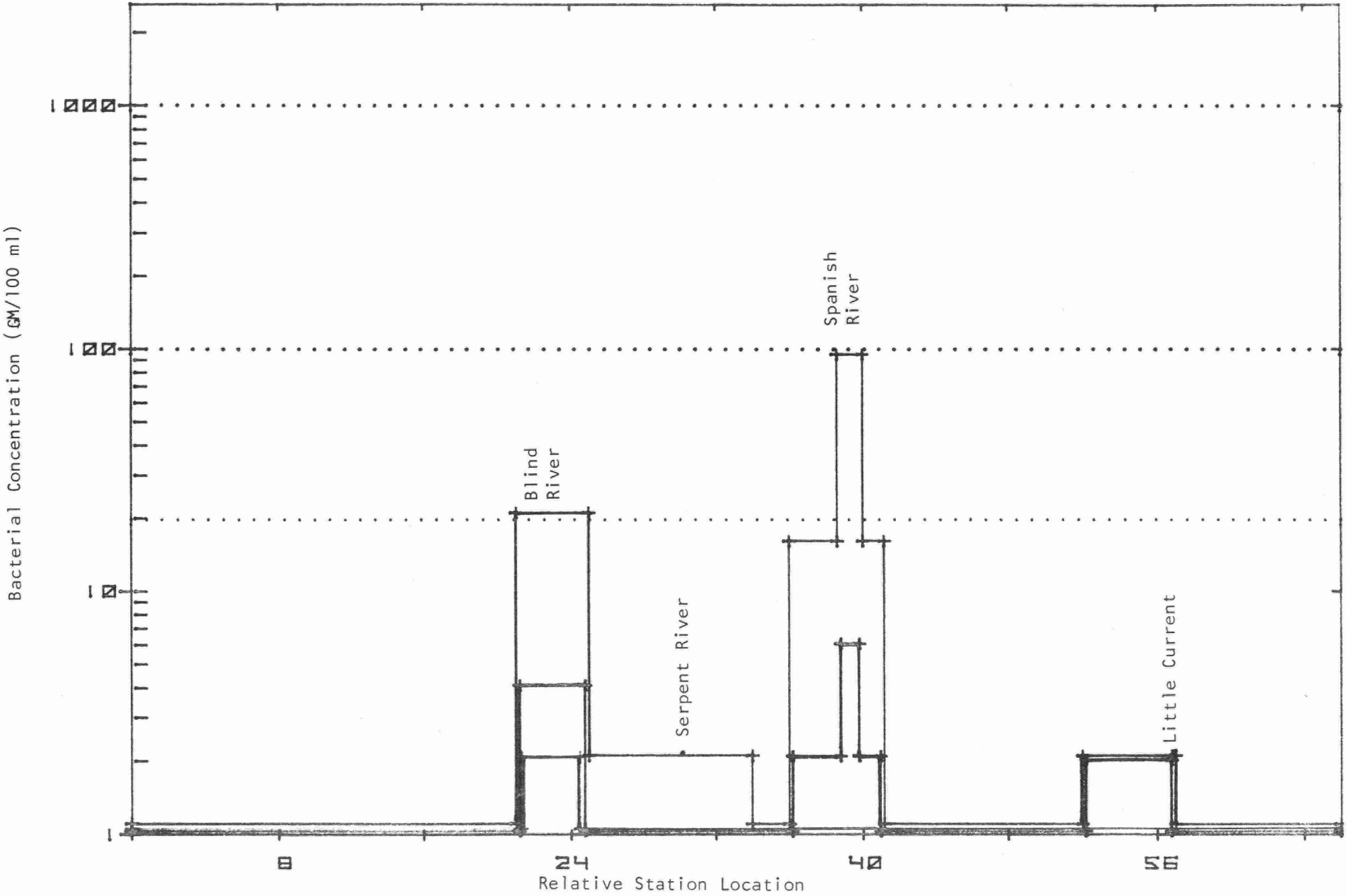


Fig 3 : Concentrations of Total Coliforms (—), Fecal Coliforms (—). and Fecal Streptococci (—) during the June 1974 Survey of the North Channel Nearshore.

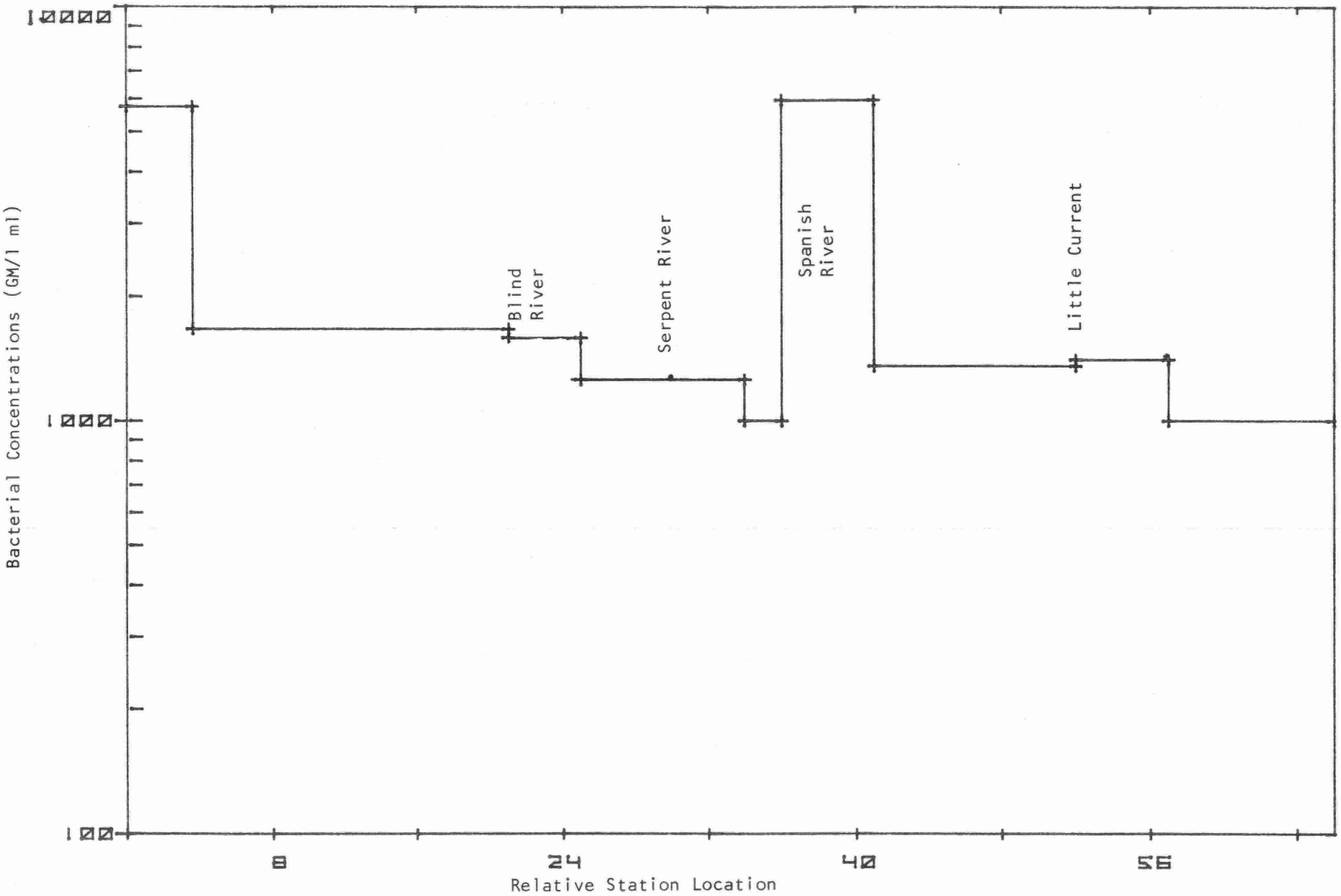


Fig 4 : Concentrations of Heterotrophic Bacteria during the June 1974 Survey of the North Channel Nearshore

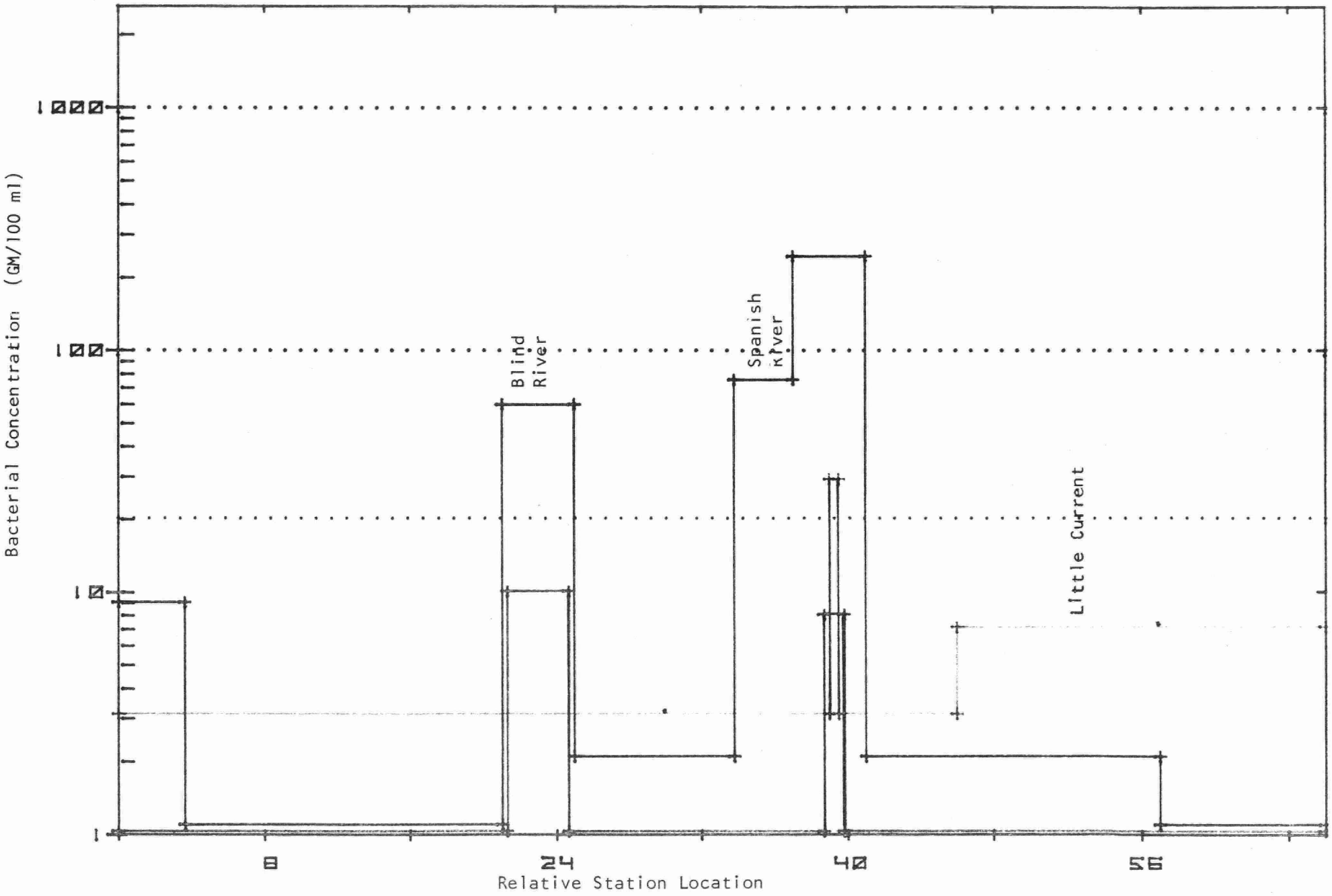


Fig 5 : Concentrations of Total Coliforms (—), Fecal Coliforms (—) and Fecal Streptococci (—) suring the July 1974 survey of the North Channel Nearshore

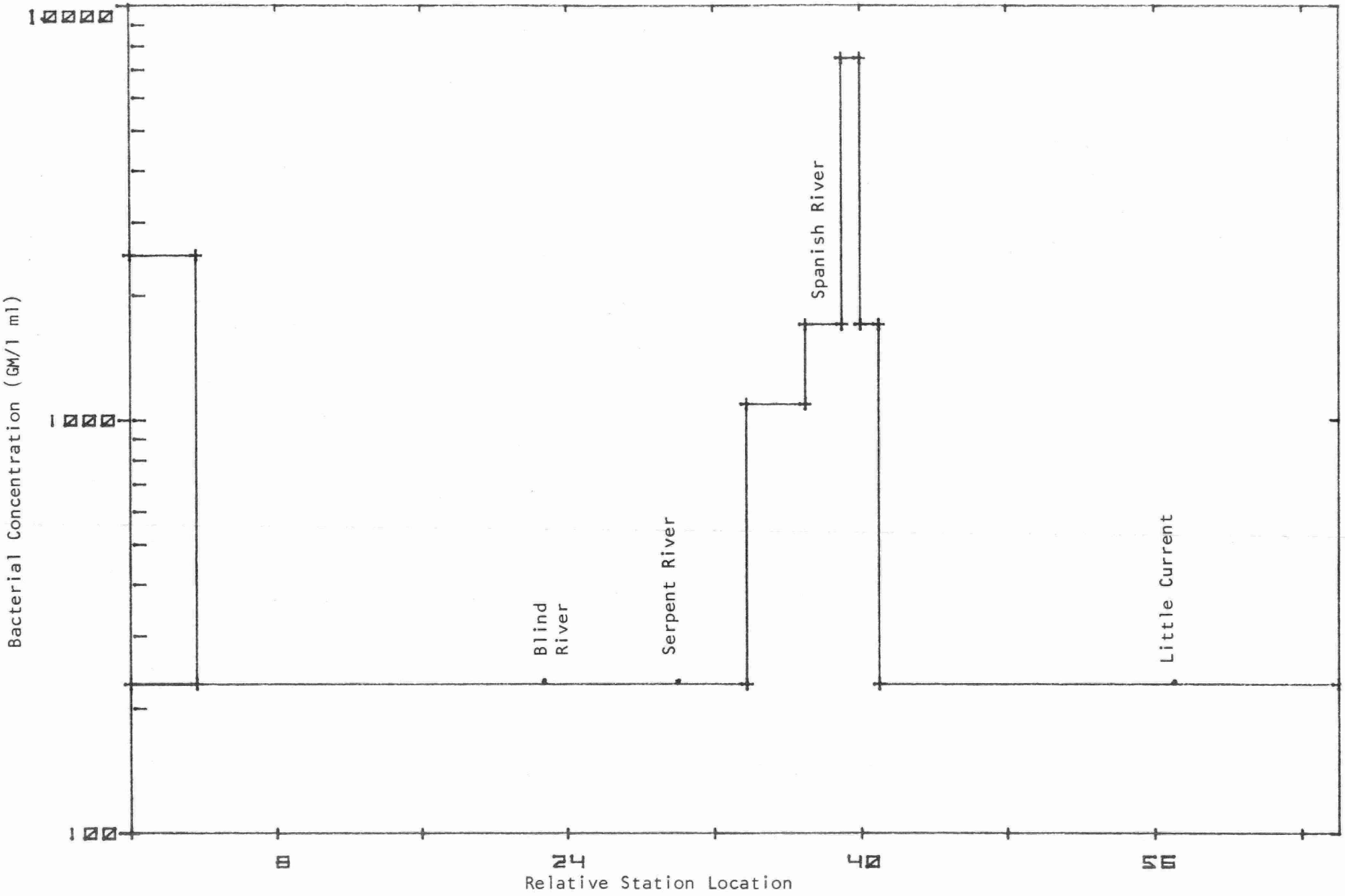


Fig 6: Concentrations of Heterotrophic Bacteria during the July 1974 survey of the North Channel Nearshore

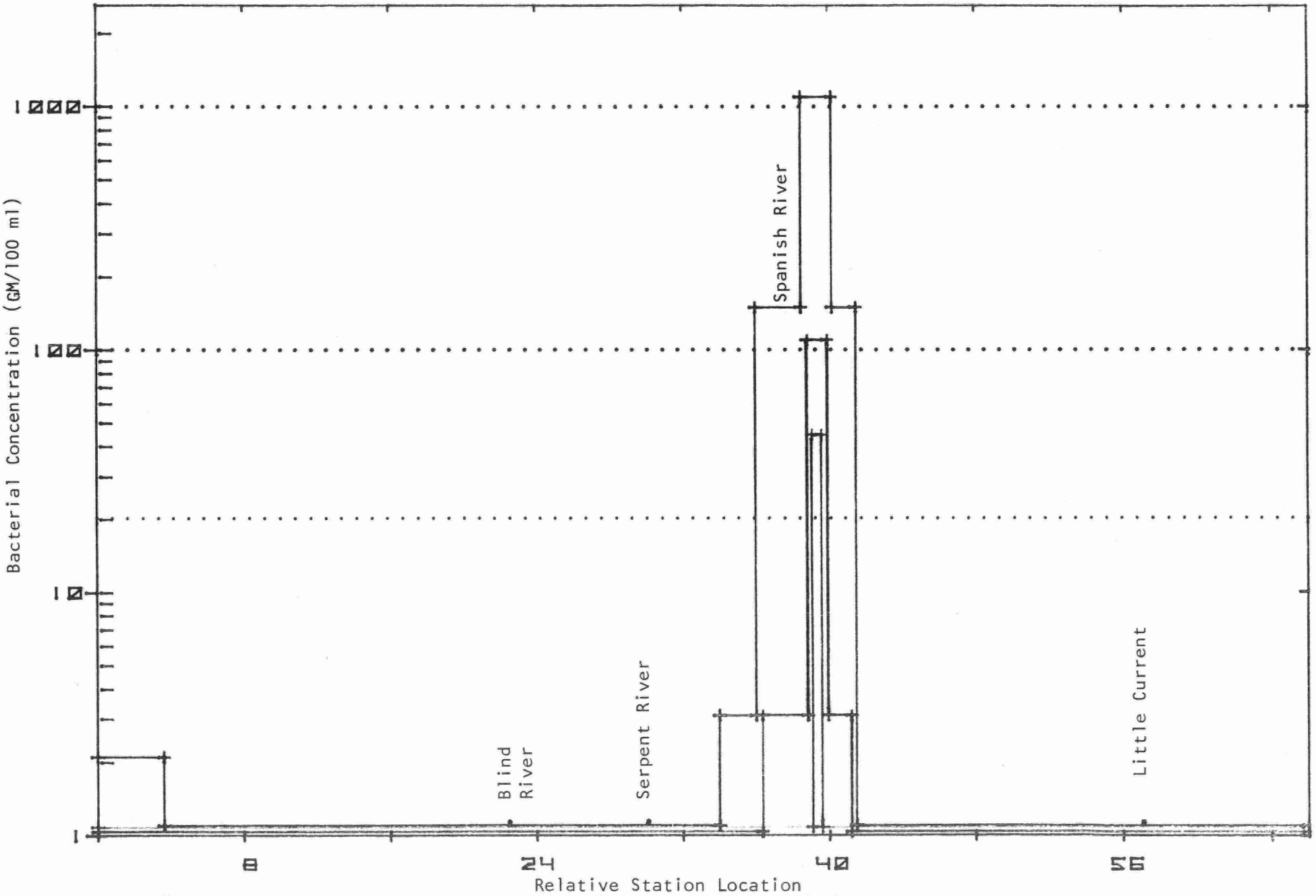


Fig 7 : Concentrations of Total Coliforms (—), Fecal Coliforms (—) and Fecal Streptococci (—) during the November 1974 Survey of the North Channel Nearshore

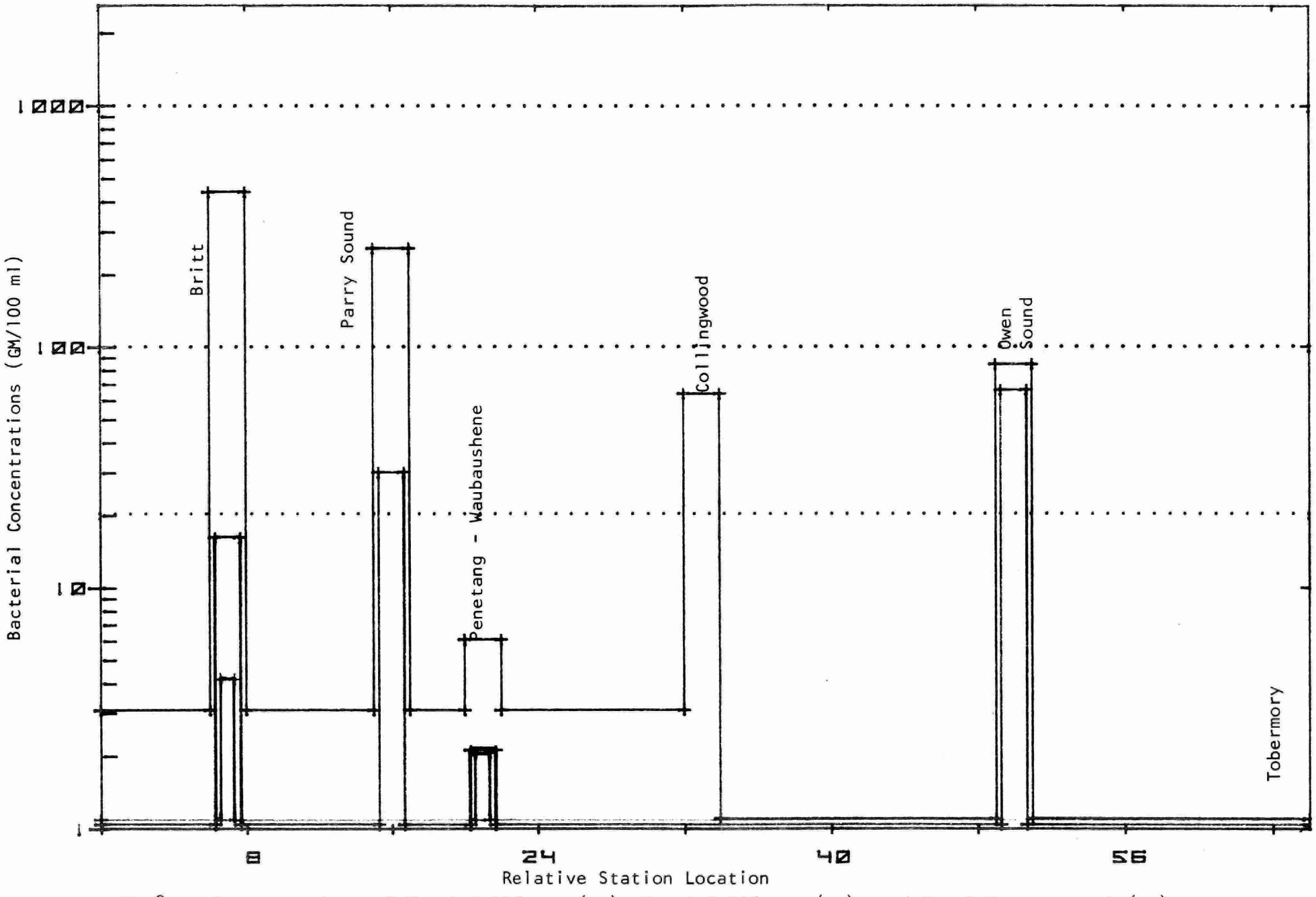


Fig 8 : Concentrations of Total Coliforms (⟶), Fecal Coliforms (⟶), and Fecal Streptococci (⟶) during the June 1974 Survey of the Georgian Bay Nearshore

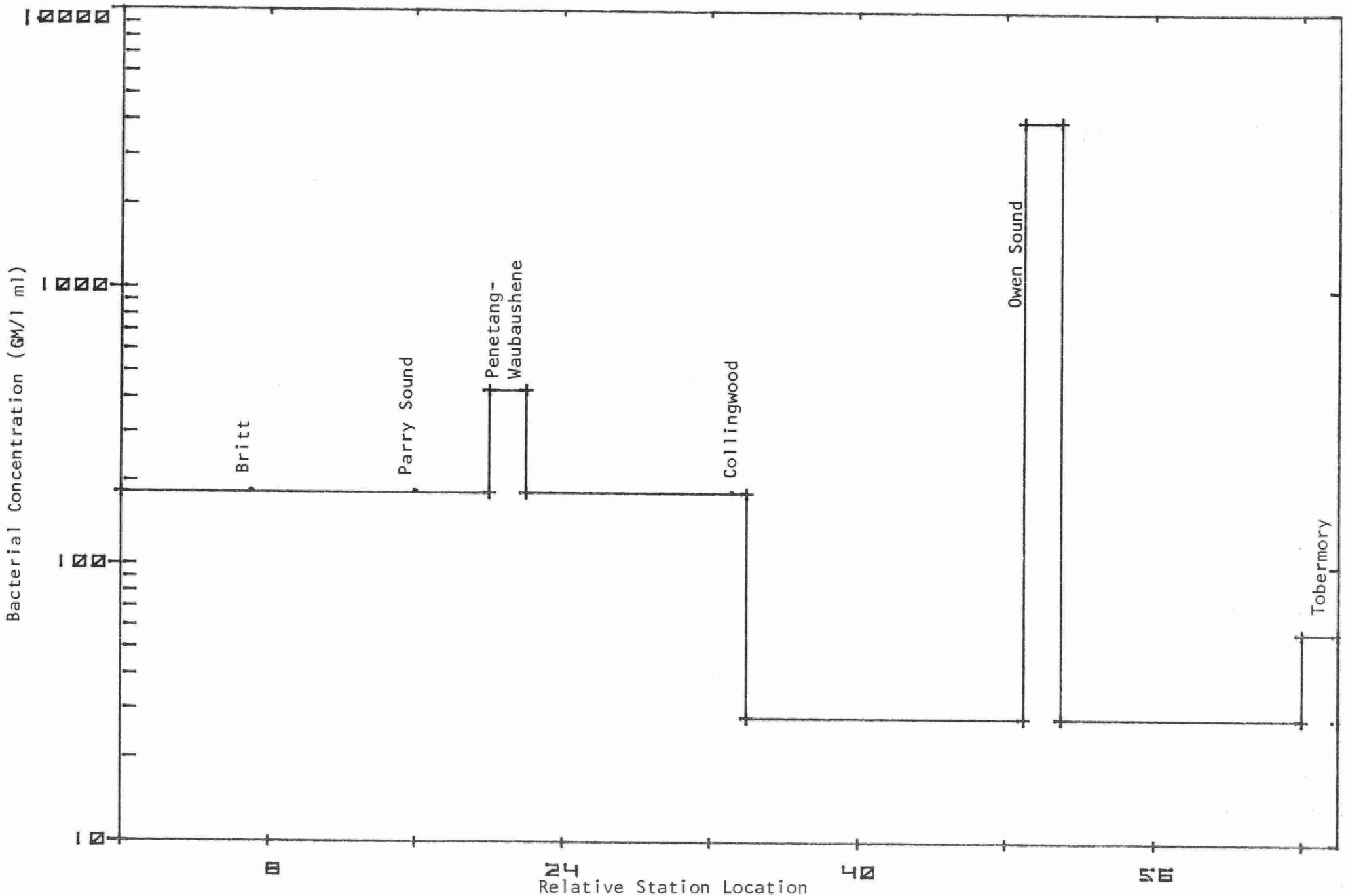


Fig 9 : Concentrations of Heterotrophic Bacteria during the June 1974 Survey of the Georgian Bay Nearshore

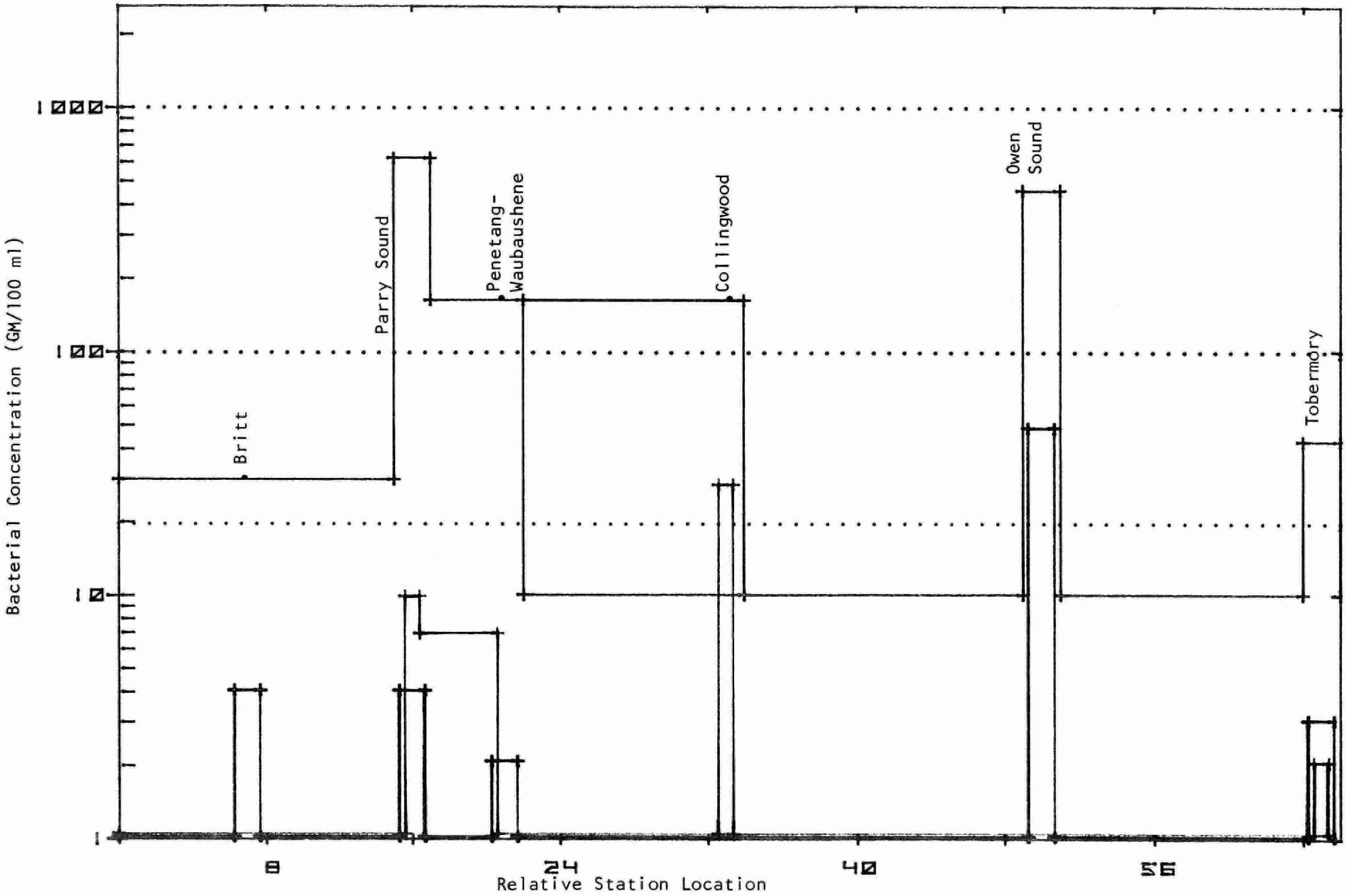


Fig 10 : Concentrations of Total Coliforms (⟶), Fecal Coliforms (⟶) and Fecal Streptococci (⟶) during the August 1974 Survey of the Georgian Bay Nearshore

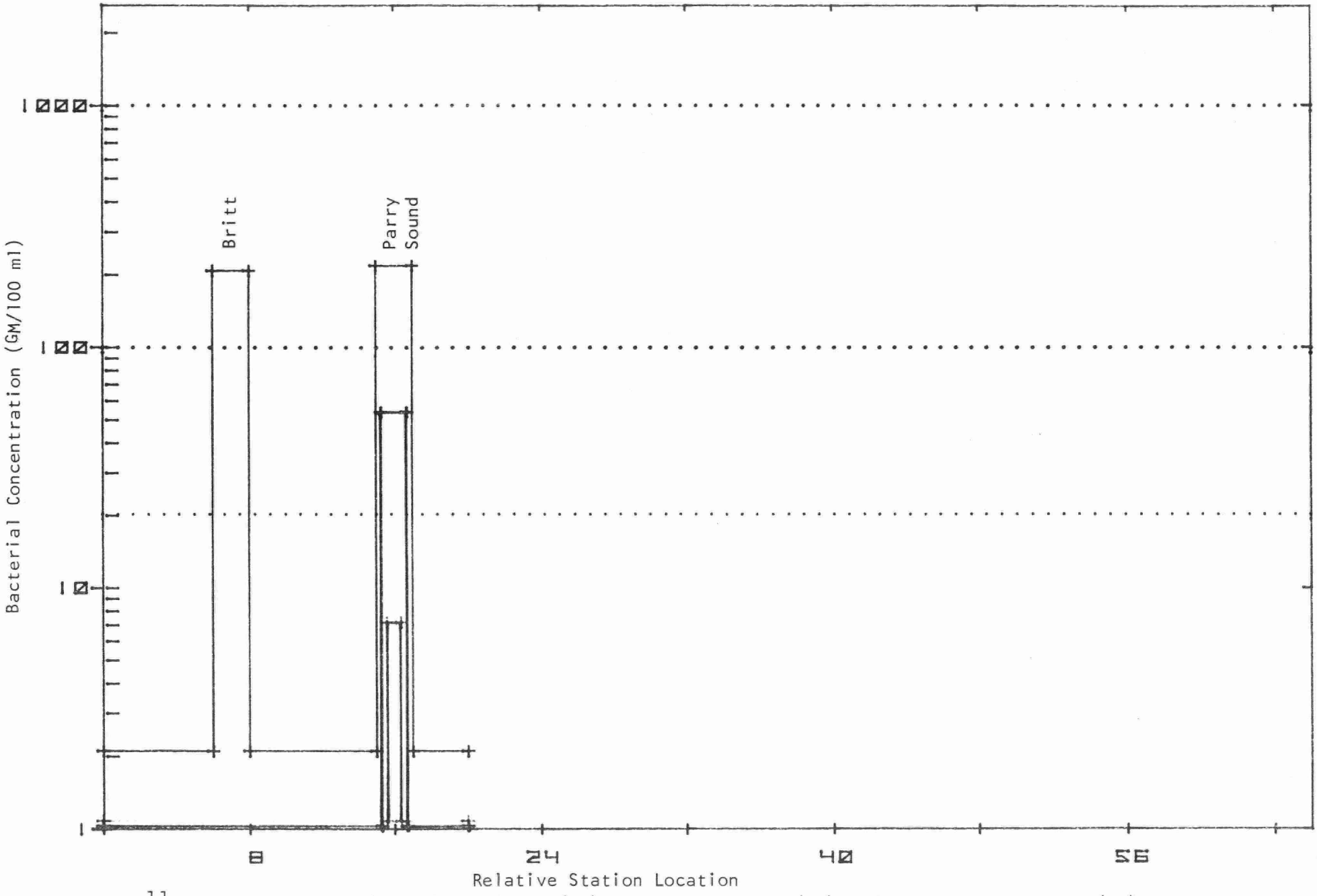


Fig 11: Concentrations of Total Coliforms (—), Fecal Coliforms (—) and Fecal Streptococci (—) During the November 1974 Survey of the Georgian Bay Nearshore

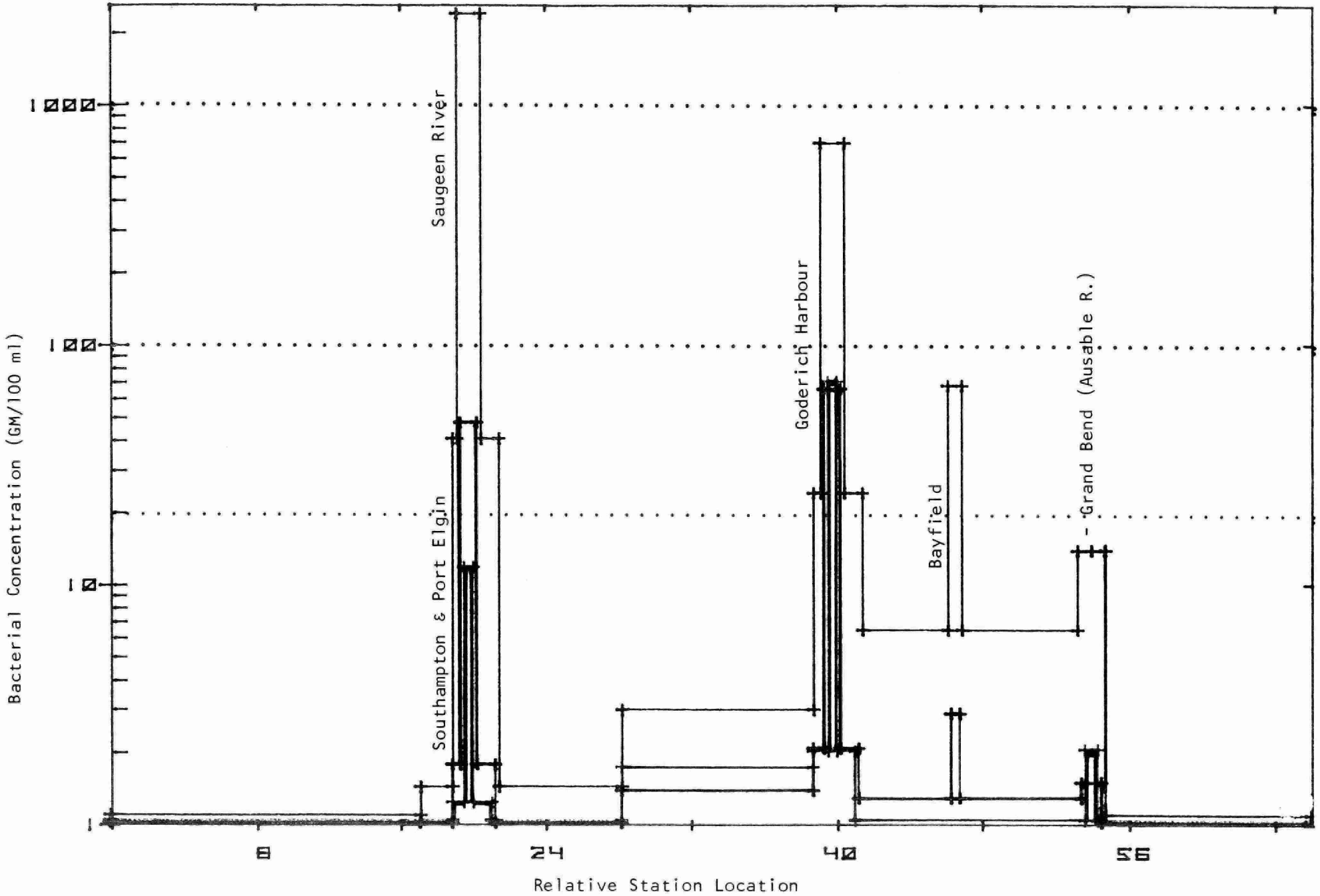


Fig 12: Concentrations of Total Coliforms (—), Fecal Coliforms (—) and Fecal Streptococci (—) during the May 1974 Survey of the Lake Huron Nearshore

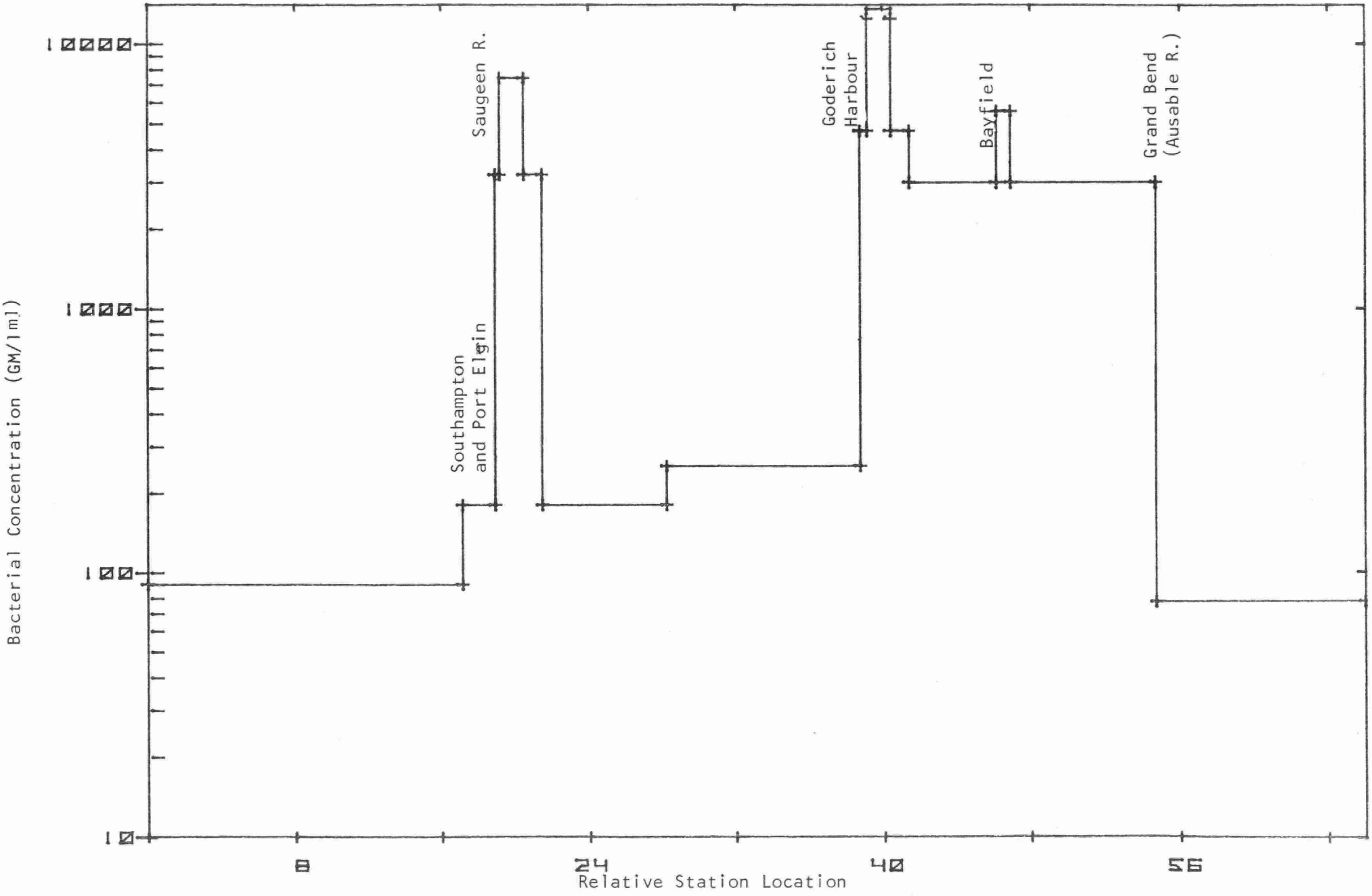


Fig 13. Concentrations of Heterotrophic Bacteria during the May 1974 Survey of the Lake Huron Nearshore.

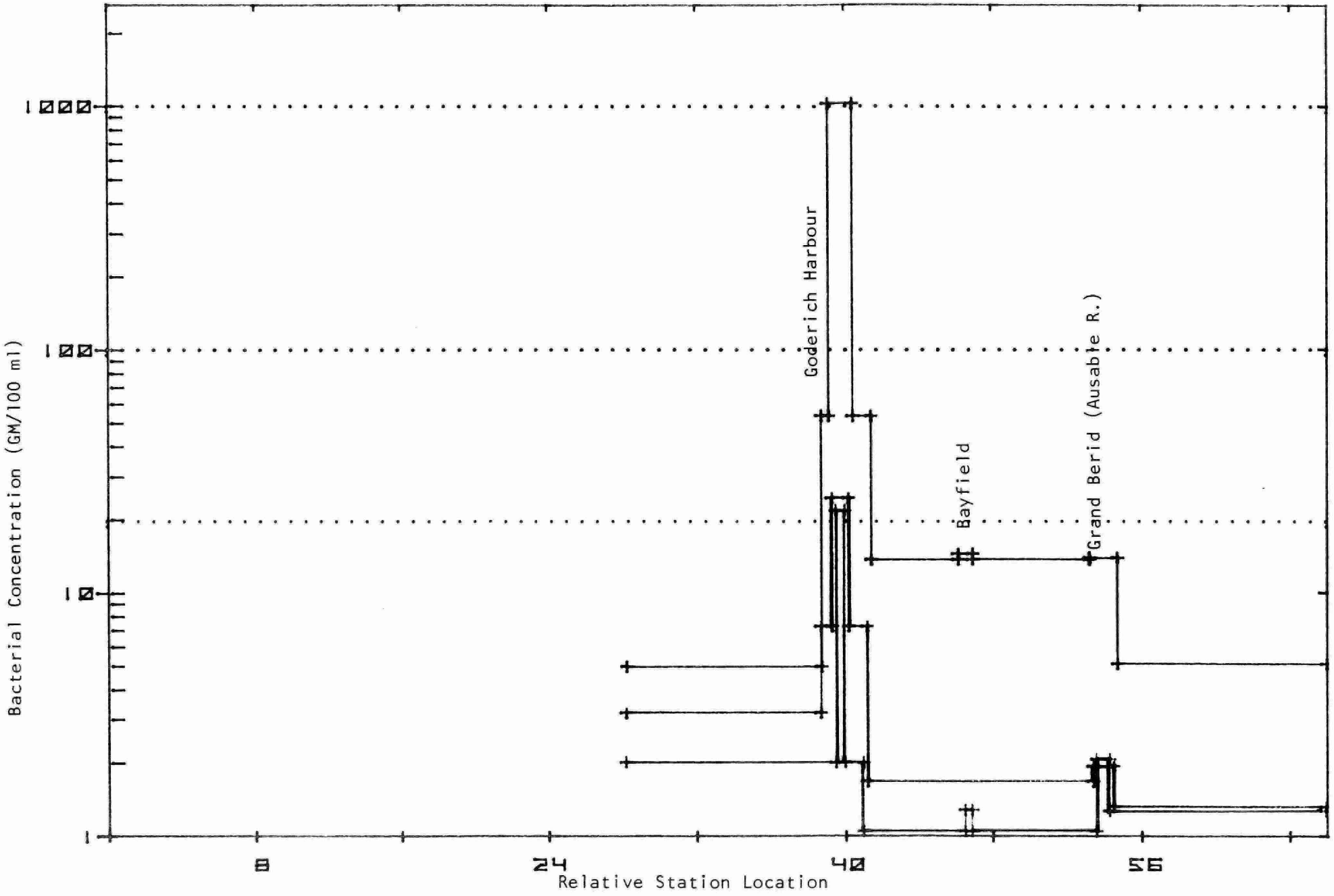


Fig 14 Concentrations of Total Coliforms (—), Fecal Coliforms (—), and Fecal Streptococci (—) during the October 1974 survey of the Lake Huron Nearshore.

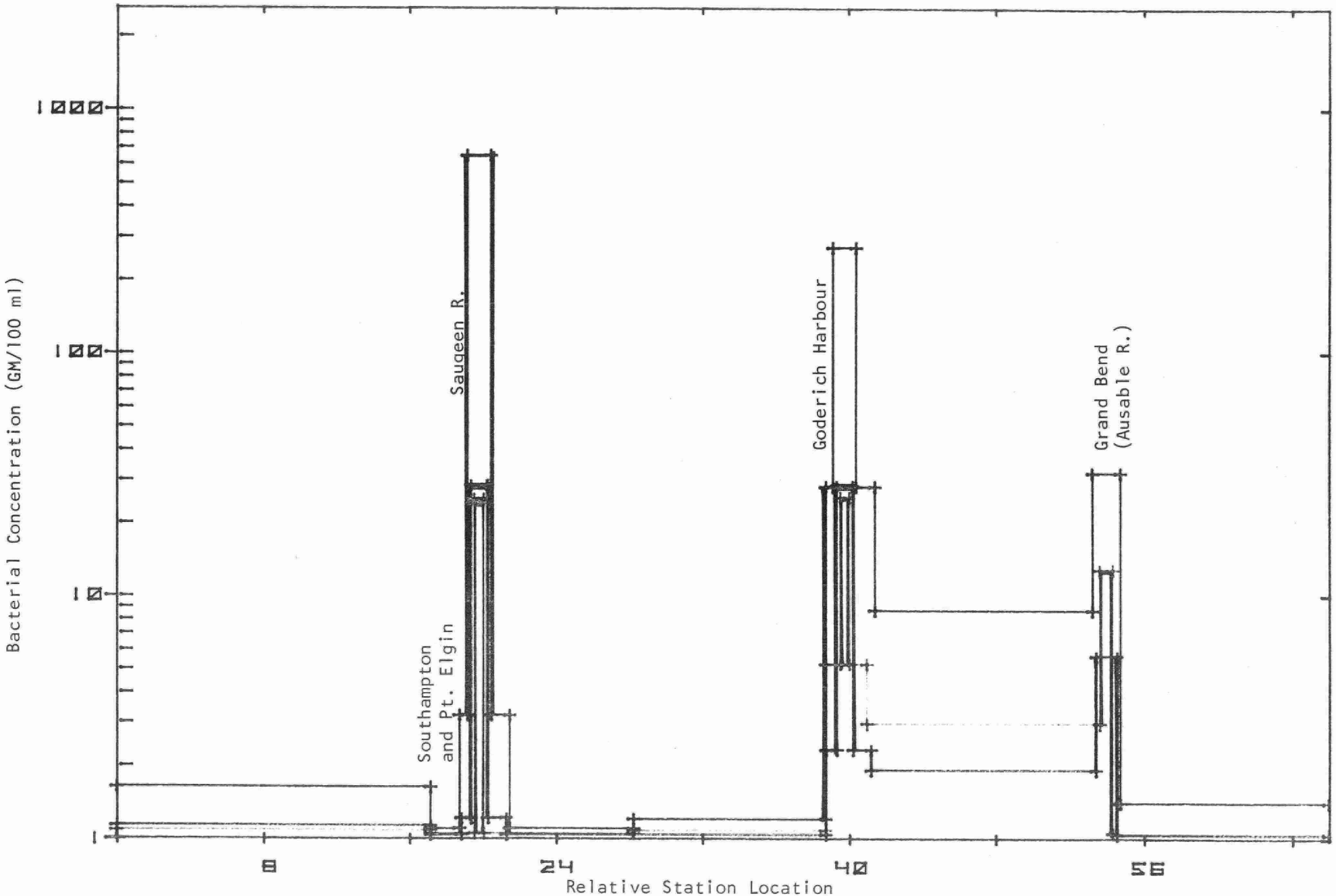


Fig 15 Concentrations of Total Coliforms (—), Fecal Coliforms (—), and Fecal Streptocci (—) during the April 1975 Lake Huron Nearshore survey.

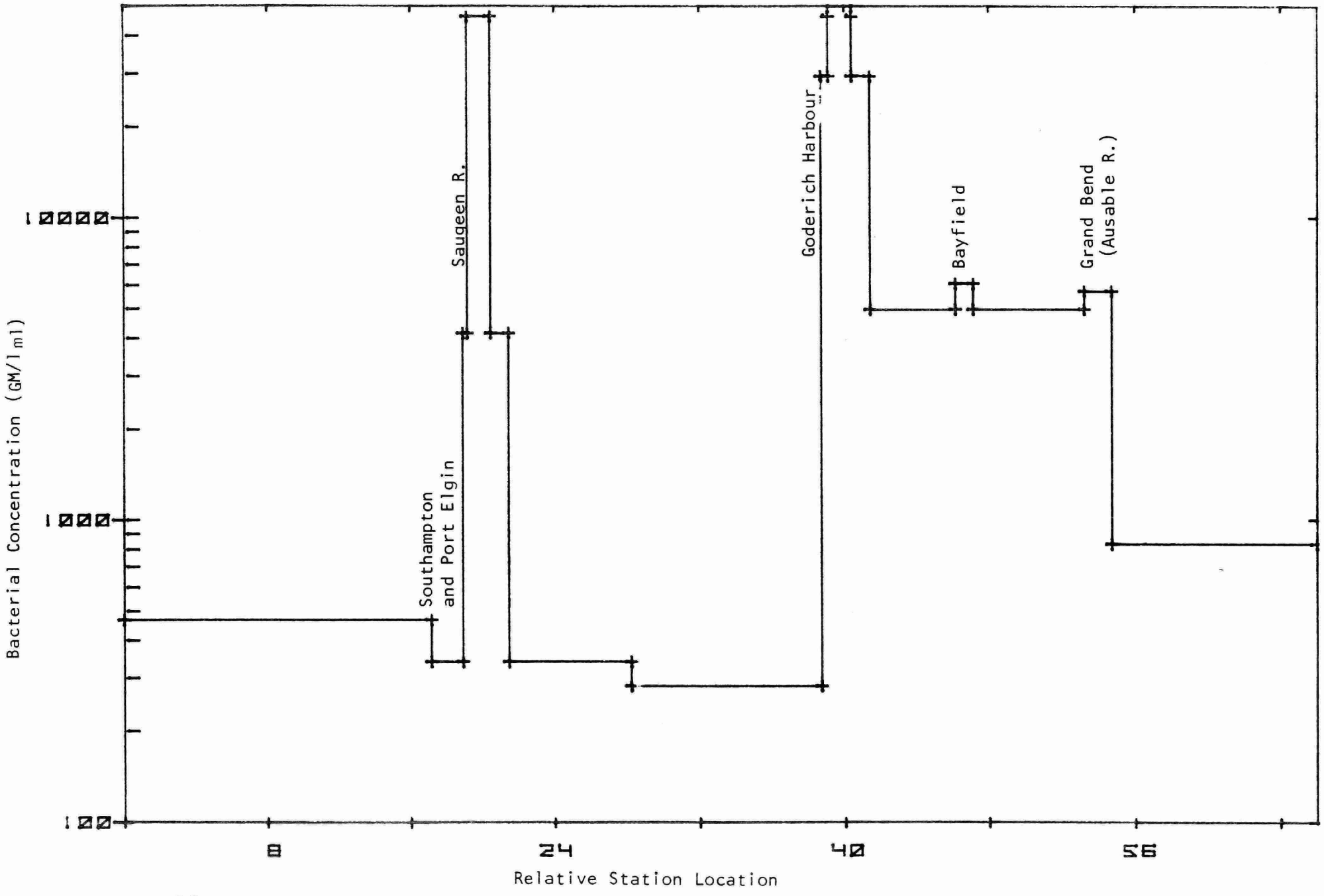
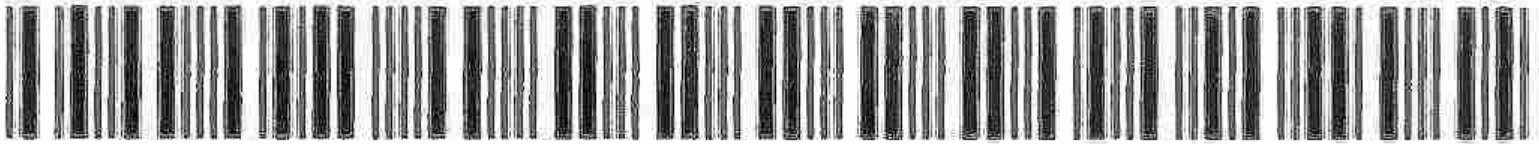


Fig16: Concentration of Heterotrophic Bacteria during the April 1975 Survey of the Lake Huron Nearshore


9693600009225